HARMSWORTH
SELF-EDUCATOR

EDITED BY ARTHUR MEE

MR PETROS CONSTANTINOU

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EDITED BY
ARTHUR MEE

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A KEY TO THE HARMSWORTH SELF-EDUCATOR

From this table of the 25 groups of the Self-Educator the student may find the place of any subject treated in the work. The main groups appear in regular numerical order in each part of the Educator, each group continuing until complete. The sub-divisions of the groups appear as nearly as possible in the order of this page.

Group 1. Success

The Secrets of a Successful Life. Personality. Applied Education. Ideas. The Qualities that Win in the World.

Group 2. Geography and Travel

GEOGRAPHY. Physical, Political, and Commercial.
TRAVEL. Educational Travel. How to See the World.

Group 3. Arts and Crafts

ART. Ideals and History of Art. The Old Masters.
DRAWING. Freehand. Object. Brush. Memory. Light & Shade.
PAINTING. Theory and Training.
DESIGN. Design in Crafts and Trades. Book-decoration. Illumination. Design for textiles, wallpapers, metal work.
SCULPTURE. Modelling. Chiselling. Casting.
ARCHITECTURE. Theory. Styles. Training.
CARVING. Wood. Bone. Ivory. Tortoiseshell.
ART METAL WORK. A Practical Course.
PHOTOGRAPHY. A Course of Simple Lessons with a Camera.

Group 4. Physiology and Health

PHYSIOLOGY. Structure and Working of the Human Body.
HEALTH. The Laws of Health and Personal Hygiene.

Group 5. Agriculture and Gardening

FARMING. A Practical Course in the Cultivation of the Earth. Live-stock. Dairying. Poultry. Beekeeping.
FORESTRY. The Theory and Practice of Managing Trees.
GARDENING. Gardens for Pleasure and Profit.

Group 6. Chemistry

CHEMISTRY. Complete Course in Theory and Practice.
APPLIED CHEMISTRY. The Applications of Chemistry in Industry. Chemical Analysis. Acids and Alkalies. Oils and Fats. Waxes. Candles. Soap. Glycerine. Volatile Oils and Perfumes. Paints and Polishes. Glues. Starch. Inks. Coal Tar Products. Wood Distillation. Celluloid. Matches. Artificial Manures. Electro-chemistry. Water-Softening. Waste Products. Artificial Silk.

Group 7. History

The Story of All Ages and Peoples for Over Ten Thousand Years—From Egypt and Babylon to Europe in 1914.

Group 8. Civil Engineering and Transit

CIVIL ENGINEERING. Surveying. Varieties of Construction. Reinforced Concrete. Roads. Bridges. Railways and Tramways. Water Supply. Sewerage. Refuse. Hydraulics. Pumps. Harbours. Docks. Lighthouses.
VEHICLES. Construction and Use. Cycles. Cabs, Buses, Trams.
MOTORS. Design and Management of a Motor Car.
AVIATION. Science and Management of Flying Machines.
RAILWAYS. The Management and Control of Railways.
SHIPBUILDING. Shipping. Design and Construction.

Group 9. Literature and Journalism

LITERATURE. A Survey of English Literature and Foreign Classics. The World's Great Books and their Writers.
JOURNALISM. How to Become a Journalist. A Guide to Newspaper Life. How to Write. The Journalist's System.
PRINTING. Composing by Hand and Machine—Linotype and Monotype. Stereotyping and Printing.
TYPE. Type Cutting and Founding.
ENGRAVING AND ETCHING. Blockmaking and Process Work.
LITHOGRAPHY. Printing from the Stone.
BOOKBINDING AND PUBLISHING. Binding and Issuing Books.

Group 10. Civil Service and Professions

CIVIL SERVICE. The Three Branches of the Public Services of the British Empire—Municipal, National, Imperial.
BANKING. The Whole Practice of Banking.
LAW. How to Become a Solicitor or Barrister.
MEDICINE. Training of a Doctor, Veterinary Surgeons. Dentists. Chemists and Druggists. Nurses.
INSURANCE. Health. Unemployment. Life. Fire. Accident.
AUCTIONEERING AND VALUING. Practical Training.
ESTATE AGENCY. Management of a Great Estate.
CHURCH. How to Enter the Ministry of all Denominations.
SCHOLASTIC. Teachers. Professors. Governesses. Tutors.
SECRETARIES. Institution Officials. Political Agents. Lecturers.
LIBRARIES. Management of Libraries. Cataloguing.
ARMY, NAVY, MERCHANT SERVICE. How to Enter Them.

Group 11. Life and Mind

BIOLOGY. The Rise of Life. Evolution. Heredity.
PSYCHOLOGY. The Mind of Man.
SOCIOLOGY. Social Conditions. Welfare of Communities.
EUGENICS. Human Betterment and the Future of the Race.

Group 12. Business

BUSINESS. The Management of a Successful Business. System. Simple Political Economy.
SHOPKEEPING. All Kinds of Shops and Small Trades.
ADVERTISING. The Value of Advertising. How to Advertise, How to Write Advertisements. How to Get Them.

Group 13. Physics and Power

PHYSICS. The Science of Matter and Motion.
POWER. Sources and Uses of Power. Air. Water. Wind. Sun. Steam. Oil. Gas. For Electricity, see Group 16.
PRIME MOVERS. Structure and Management of all Engines.

Group 14. Building Trades

BUILDING. The Building Trades and Building Materials: their Manufacture and Use. Building a House. Excavating. Drainage. Bricks, Limes, and Cements. Bricklaying. Clay Wares. Reinforced Concrete. Masonry. Carpentry. Slates and Tiles. Plumbing. Joinery. Foundry and Smith's Work. Painting. Papering and Glazing. Heating. Lighting. Ventilation. Quantity Surveying.
WOOD-WORKING MACHINERY. The Machines Used in Working Wood: Sawing, Turning, Planing, Moulding.
CABINET-MAKING AND UPHOLSTERING.

Group 15. Natural History

BOTANY. Flowers. Plants. Seeds. Trees. Ferns. Mosses. Fungi.
ZOOLOGY. Mammals. Birds. Fishes. Reptiles. Insects. Lower Forms of Life.
BACTERIOLOGY. The Story of Microbes. Bacteriology in Relation to Health and Industry.

Group 16. Electricity

ELECTRICITY. Its Development and Countless Applications. Electrical Engineering.
TELEGRAPHS AND TELEPHONES. The Instruments and How to Operate Them.
WIRELESS TRANSMISSION. The Main Systems and their Methods of Working.

Group 17. Music

OLD NOTATION AND TONIC SOLFA. Tuition in All Instruments. Orchestration.
ELOCUTION AND SINGING. The Voice and its Treatment.
MUSICAL INSTRUMENTS. Their Design and Manufacture.

Group 18. Manufactures

TEXTILES. The Textile Trades from Beginning to End. Cotton. Wool. Silk. Hemp. Flax. Jute. Carpets.
LEATHER. The Leather Industry. Tanning. Boots and Shoes. Saddlery. Belting. Gloves. Sundry Leather Goods.
GLASS. Manufacture of All Kinds of Glass. Stained Glass.
EARTHENWARE. The Craft and Industry of Pottery.
PAPER. Papermaking of All Kinds.
RUBBER. The Source and Preparation of Rubber, and Manufacture of Rubber Goods.
TOBACCO. Cultivation and Manufacture. Tobacco Pipes.
FOOD SUPPLY. Milling. Breadmaking. Biscuits and Confectionery. Sugar. Condiments. Fruit. Fisheries. Food Preservation.
BEVERAGES. Tea. Coffee. Chocolate. Cocoa. Brewing. Wines and Ciders. Mineral Waters.
BASKETMAKING. CORK. WATTLE. CANE. BARKS. BRUSHES.

Group 19. Astronomy. Geology. Archæology

ASTRONOMY. The Universe as We Know It. Millions of Worlds. A Survey of the Solar System.
GEOLOGY. The Structure of the Earth. Petrology. Crystallography. Palæontology.
ARCHÆOLOGY. Buried History. The New Story of the Old World as Revealed by the Excavator.

Group 20. Mechanical Engineering

ENGINEERING. Applied Mechanics. Workshop Practice. Machine Tools. Machines and Appliances. Cranes.
DRAWING for Coppersmiths, Tinmen, and Boilermakers.

Group 21. Languages

LATIN. ENGLISH. FRENCH. GERMAN. SPANISH.

Group 22. Dress and Housekeeping

DRESS. Principles of Dressmaking. Underclothing, Tailoring. Millinery. Hatters. Furs and Feathers
HOUSEKEEPING. Domestic Management. Servants and their Duties. Cookery. Laundry.

Group 23. Metals and Minerals

METALS. Metallurgy. Properties and Characteristics of Metals. Iron and Steel. Copper. Tin. Zinc. Precious Metals.
METAL MANUFACTURES. Arms and Ammunition. Cutlery. Clocks and Watches. Jewellery. Scientific Instruments.
MINERALS. Mineralogy. Properties and Characteristics of Minerals.
MINING. Coal. Gold. Diamonds. Tin.
QUARRYING. The Appliances and Processes of Extracting and Preparing Stone.
GAS. The Process of Manufacture.
PETROLEUM. Extraction and Refining Processes.

Group 24. Clerkship

ACCOUNTANCY. Complete Training. Bookkeeping.
SHORTHAND. Pitman's System, with Latest Improvements
TYPEWRITING. Working and Management of All Machines

Group 25. Mathematics

Arithmetic. Algebra. Simple Graphs. Euclid. Trigonometry.

Coalfields and their Resources. Petroleum and its Uses. Iron and Steel. Gold and Silver. Other Metals. Precious Stones.

THE WORLD'S MINERALS

Coal is derived from the vegetation of past geological epochs, subjected for vast periods of time to great pressure and heat. The result of a long series of slow chemical changes is to get rid of a large proportion of the hydrogen and oxygen, and to increase the proportion of carbon [see Natural History]. *Peat*, abundant in the bogs of Ireland and other parts of the world, shows an early stage of the process. The fibrous arrangement is still clearly seen. There is a large proportion of water, and owing to the smaller proportion of carbon the heating power of compressed peat is only about one quarter of that of coal. *Lignite*, with 70 per cent. or less of carbon, is intermediate between peat and coal, but the harder varieties, known as brown coal, closely resemble the latter. Some of the vast lignite deposits of North America are an excellent substitute for coal.

The Two Kinds of Coal. Of coal there are two well-marked kinds—soft or bituminous coal, with 50 per cent. or more of carbon, and anthracite, with as much as 94 per cent. *Bituminous coal* lights readily, burns with a flame, and produces a varying amount of smoke. Its varieties are very numerous, one of the best marked being the well-known cannel coal. *Steam coal*, intermediate between bituminous coal and anthracite, contains little bitumen, so that it is smokeless, while the high proportion of carbon gives great heating power. This steam coal is in great demand for naval use. *Anthracite* is hard to light, burns without flame, and gives out great heat. Its smokelessness makes it very suitable for use in cities, as in the United States. It is also used in brewing.

Coke is produced by heating bituminous coal away from the air. The volatile substances are driven off, and the residuum approximates in properties to anthracite. Coke is an important by-product in the manufacture of coal gas. It burns with intense heat, and its freedom from sulphur makes it valuable in many metallurgical operations. Coals are often spoken of as coking, or non-coking. The former, which cake or fuse in burning, are preferred for special purposes—for example, as fuel for locomotives.

Growth of the Use of Coal. The use of coal is of no great antiquity in Europe. Whatever may have been the case locally, it was not used in London before the thirteenth century. In the seventeenth century the total production in England had reached over 2,000,000 tons. The introduction of steam power enormously increased the consumption of coal, and resulted in a redistribution of population in England and other countries.

Coalfields of the World. Estimates of the total area of the world's coalfields differ widely. The area can hardly be far under 500,000 sq. miles. According to Mr. Chisholm, there are approximately 250,000 sq. miles in North America, chiefly in the United States. The coalfields of China cannot be less than 200,000 sq. miles, and may be more. The coalfields of Britain may be put at about 12,000 sq. miles, while those of the Empire are roughly 140,000 sq. miles. Russia has about 20,000 sq. miles; Spain, 5,000; France, Germany and Austria-Hungary, round about 2,000; and Belgium, 500 sq. miles. Area, however, affords no satisfactory basis for estimating the actual resources. Much coal lies at a depth impossible to work, as, for example, on the South Wales coalfield, where the coal-bearing strata are 10,000 ft. thick. In other cases the seams may be so thin as not to pay for working, or the quality may be inferior. Temperature increases rapidly though not uniformly with the depth of a mine, rendering extraction beyond a certain depth a physical impossibility [see Mining]. The element of cost has also to be taken into account in deep mining. At the present time a depth of 4,000 ft., and a seam thickness of 2 ft. are commonly assumed as working conditions. No mine yet reaches this depth, though the deepest mines of this country and of Belgium are not far short of it.

How Long Will Our Coal Supply Last? The ever increasing demand for coal has led to investigations into the probable duration of our coal supply. Two Royal Commissions have reported on the subject, the second in 1904. On the workings of 1903 our reserves would apparently last for 600 years, but the output is not likely to remain steady. More probably it will reach a maximum within no distant period, and then almost imperceptibly decline owing to the gradual increase of working cost.

The largest coalfields of Britain are those of (1) Central Scotland, in the rift valley between the Scottish Highlands and the Southern Uplands; (2) South Wales; and (3) the marginal coalfields of the Pennines in the north-east, south-east, and south-west.

The Coalfields of Scotland. The Scottish coalfield is divided into the Ayrshire coalfield, the Central, or Forth and Clyde coalfield; the Fife coalfield; and the Midlothian coalfield. The estimate furnished to the Royal Commission of 1904, was that more than 15,000,000,000,000 tons are available, including workable coal under the Firth of Forth. The bulk of this is in the counties of Fife (with Kinross), Lanark, the

Lothians, Stirling, and Ayrshire. The output for 1913 was 42,500,000 tons, two-fifths of which came from Lanarkshire, which feeds the great industrial region of which the Clyde is the centre and outlet.

The South Wales Coalfield. The South Wales coalfield ranks next in size, with an area of over 900 sq. miles. Deeply cut valleys penetrate into this mountainous region, bringing the outcrop to the surface and enabling the seams to be worked cheaply. This explains why the mines are long and shallow as compared with those of the North of England, though many are now carried to over 10,000 ft. The ports at the mouths of the valleys, of which the most important are Llanelly, Swansea, Cardiff, Barry, and Newport, are well placed for exporting coal cheaply. Much is used locally for iron smelting, the tinplate and other manufactures. The eastern part of this field consists of bituminous coal. The centre supplies most of the steam coal for the Navy, while anthracite is mined in the western part. More than 26,000,000,000 tons are estimated to be available within 4000 ft,, half being steam coal. At the rate of output in 1903 (42,000,000 tons) this would last about 600 years. In 1913 the production amounted to nearly 57,000,000 tons, forming 19.8 per cent. of the total output from the United Kingdom.

The Coalfields of the North of England. The coalfield of Yorkshire, Derby, and Nottingham, the largest in England, is about 750 sq. miles in area. The Silkstone is one of the best seams. It is continuous with the Arley coal of the Lancashire coalfield, and must originally have covered an area of 10,000 sq. miles. The Barnsley coal is of a semi-anthracite character, developing a great heat either as engine or smelting fuel. The estimated amount of workable coal in 1903 was over 26,000,000,000 tons, available for 500 years at the rate of 1903 (52,000,000 tons). This coalfield supplies the Yorkshire woollen and iron industries. In 1913 the output was 74,000,000 tons, or 25·8 per cent. of the total for the whole country.

The Durham and Northumberland coalfield also lies east of the Pennines. The seams which run under the sea might probably be followed for about three miles. A famous seam is the Wallsend, five or six feet thick. Newcastle coal is in great demand in London, and also locally for the vast iron industries of the Tyne and Tees. The output in 1913 was over 56,000,000 tons. The area of visible coalfields was estimated at 460 sq. miles, in addition to 225 sq. miles of concealed coalfields and 111 sq. miles under the sea. The amount of workable coal was estimated in 1903 at nearly 9,000,000,000 tons.

Two important coalfields, those of Cumberland and Lancashire, lie on the western flank of the Pennines. In the Cumberland coalfield all the coal lies within 2000 ft. of the surface. It is chiefly mined round Whitehaven, Workington, and Maryport, and the workings have been carried about three miles under the Irish Sea. The amount of coal available has been estimated at 1,500,000,000 tons, which at the rate of 1903 (over 2,000,000 tons) would last about 700 years.

The South Lancashire coalfield, which extends into Cheshire, is an irregular area of over 200 sq. miles. Its output in 1913 was not far short of 25,000,000 tons, a large part of which feeds the great cotton and iron industries of Lancashire. The southern part of this coalfield is one of the most densely populated parts of Europe. The estimated reserve is 4,340,000,000 tons.

Coal for the Black Country. The North Staffordshire coalfield is not very large (75 sq. miles), but it has thick seams of workable coal. The coal-bearing strata are perhaps 5000 ft. thick, with a total thickness of workable seams amounting to nearly 3000 ft. Workings are carried down to nearly 3000 ft. This region is not yet developed to anything like the extent possible, since few districts in the United Kingdom are so richly endowed with mineral wealth. The South Staffordshire coalfield, on the contrary, once enormously rich, has been much depleted to feed the furnaces of the Black Country. The whole country between Wolverhampton, Dudley, and Birmingham forms one great workshop [see **68**, page 820]. Professor Hull has vividly described the scene at night, as viewed from the walls of Dudley Castle, in the centre of the coalfield: "The whole country within a radius of five or six miles is seen to be overspread by collieries, iron-foundries, blast-furnaces, factories, and the dwellings of a dense population, and from amidst the thick, smoky atmosphere the tongues of fire from the furnaces shoot up an intermittent light which illumines the whole heavens. But the spectacle does not represent the whole sum of human labour, for whilst 10,000 hands are at work above ground, one half as many, perhaps, are beneath the surface, hewing the coal which is to be the prime mover of the whole machinery in motion above ground." The total thickness of the workable seams in the Dudley district is about 65 ft., a famous seam being the Ten-yard, with a general thickness of 30 ft. Probably nine-tenths of this rich seam are now worked out, drowned, or otherwise destroyed. In this area of 93 sq. miles there are perhaps 1,350,000,000 tons still available. In 1913 over 14,000,000 tons were raised in the two Staffordshire coalfields.

The Warwickshire coalfield has the advantage of being the nearest to London. The area at present worked is about 30 sq. miles, with perhaps 30 ft. of workable seams. It may yield nearly 850,000,000 tons. The output in 1913 was just over 5,000,000 tons.

Some Minor Coalfields. The Bristol coalfield, which extends to Gloucester and over much of Somerset, has two series of coal-bearing strata, separated by harsh sandstones. The total area has been put down at 150 sq. miles, of which all but 45 sq. miles are concealed by more recent formations. The output in 1913 was about 1,250,000 tons, and it is estimated that over 4,000,000,000 tons might be available. Of this more than one-eighth is steam coal, suitable for the Navy.

There are numerous smaller coalfields, such as those of North Wales, Coalbrookdale, the Forest of Dean, and the recently discovered deposits in Kent from which nearly 60,000 tons were obtained in 1913. The total output for the whole of England in 1913 was practically 200,000,000 tons, while Wales produced about 45,000,000 more. The total for England and Wales was thus nearly 245,000,000 tons, giving a total for Great Britain of over 287,000,000 tons, the value at the pit's mouth being £145,000,000.

The Irish coalfields are small and little developed. The most important are those of Dungannon in Ulster, and of Kilkenny in Leinster. The output in 1913 was only 82,000 tons. About 175,000,000 tons are estimated to exist.

Total Coal Resources of Britain. The recent Royal Commission estimated that there

existed reserves of coal amounting to nearly 101,750,000,000 tons in visible coalfields and to over 39,000,000,000 tons in concealed coalfields. This vast amount, enough at the rate of 230,000,000 tons a year to last for six centuries, includes none more than 4000 ft. below the surface, or more than three miles under the sea. The value of the estimated output is about £95,000,000 annually.

The quantity of British coal exported has for several years exceeded 65,000,000 tons. In 1913 it was over 76,000,000. This does not include bunkerage for consumption on board ship, which amounted in 1913 to over 21,000,000 tons, making a total of nearly 97,000,000 tons, or over 30 per cent. of the output. France, Germany, and Italy are the largest importers.

For a list and map of the British coalfields, see pages 820, 821, and 1070; and for coal as an index of the producing power of nations, see page 866.

Russian Coalfields. The coalfields of Russia are nearly twice as great in area as those of Britain; those of Spain are less than half as great as our own. Here, again, area is not the proper basis of calculation, for Germany, with less than one-tenth of the actual area of the Russian coalfields, is the third largest producer in the world.

The coalfields of Russia are found (1) in Southwest Poland; (2) in the Donets basin, covering an area of over 10,000 sq. miles, the most important coalfield, with an annual output of over 20,000,000 tons; (3) in Central Russia round Moscow; and (4) in the Urals. Beyond the confines of European Russia are the coalfields of the Caucasus and the Altai. The Moscow, Donets, and Polish coalfields are all developing rapidly. The present output of Russia is about 30,000,000 tons, valued at nearly £15,000,000.

Spanish, French, and Belgian Coalfields. Between Santander and Oviedo is the potentially rich coalfield of Asturias, with 60 workable seams of good quality. There are also rich deposits in Eastern Spain. The present output, however, is small, being about 3,000,000 tons, valued at less than £2,000,000.

The important Franco-Belgian coalfield stretches from near Aachen to Calais (210 miles), where the strata dip beneath the Channel, to reappear near Dover and in the Bristol coalfield. On this coalfield are the iron towns of Liége, Namur, and Mons in Belgium, the cotton town of Lille in France, and many smaller industrial towns in both countries. The total area is about 1200 sq. miles, but the strata are in places interrupted by or buried beneath the chalk.

In Central France, on the flanks of the Central Plateau, are many small fields, of which St. Etienne is the busiest centre. This also supplies the silk industry of Lyons.

The present output of France exceeds 40,000,000 tons, valued at £25,000,000. The Belgian output is 22,000,000 tons, valued at £15,000,000.

The Coalfields of Central Europe. The Saar coalfield (900 sq. miles), occupying the valley of the Saar, a right-bank tributary of the Moselle, supplies the rapidly growing industries of Alsace-Lorraine. The strata probably descend to 20,000 ft., so that the full resources can never be utilised.

The Westphalian or Ruhr valley coalfield is the most important in Germany, extending from the Rhine at Duisburg and Ruhrort for about forty miles up the Ruhr valley. The great iron towns of Essen and Barmen-Elberfeld are on the coalfield, which also exports coal by the Rhine.

The other important coalfields are in Saxony, on the flank of the Erz Gebirge, or Ore Mountains, and in Silesia, on the flanks of the Riesen Gebirge, and in the extreme south-east at the western end by the Polish field. The total output of Germany is about 175,000,000 tons, valued at £92,000,000. In addition there is an annual production of 80,000,000 tons of brown coal, or lignite, valued at about £9,000,000.

In Austria-Hungary coal is found in Bohemia, Moravia, and Silesia, in the flanks of the Central European Highlands. There is practically no coal in the Alpine provinces, but some lignite is found in Styria. The output of coal is 16,000,000 tons, of the value of nearly £7,000,000; 26,000,000 tons of brown coal are also produced, valued at about £6,000,000.

In the other countries of Europe, coal production is unimportant.

The Coalfields of Asia. China probably possesses the largest and richest coalfields in the world. The province of Shansi, in Northern China, has seams of coal 40 ft. thick, and easily accessible. Iron is also abundant, and the whole region is destined to become a second and richer Pennsylvania. The deposits are continued in the adjoining province of Honan. In the Yangtse basin of Central China, and especially in the Red Basin of Szechwan, coal is exposed in the gorges of the Yangtse and its affluents, needing only to be followed by adits, as in South Wales. There are also coalfields in Hunan and Kwangtung in Southern China, in Manchuria, and in Korea. The present output in China is estimated at 13,000,000 tons, of which nearly half is anthracite. Japan has coalfields in Kiushiu, Yezo, and Formosa. The Japanese output of 19,000,000 tons is valued at over £6,000,000. In Tongking there are coal-seams 70 ft. thick. Still farther south, coal is found in Borneo.

Coal is found in many parts of India, but most abundantly in Northern India. The most important coalfield at present worked is that of Raniganj (500 sq. miles), which is situated about 120 miles from Calcutta. The output of India is at present over 14,000,000 tons.

Australasian and African Coalfields. Important coalfields lie between the Great Dividing Range and the Pacific Ocean, in New South Wales and Queensland. Newcastle, at the mouth of the Hunter River, is the outlet for the mines of that district. At Brisbane, the capital of Queensland, says Professor Hull, quoting the famous Australian geologist Clarke, "steamers can load by lying literally at the mouth of the mines," for the coal-seams are exposed close to the sea, and are accessible by adits. Tasmania is also well provided with coal. In New Zealand, North Island has considerable deposits of lignite, while South Island has both lignite and coal.

Africa is poorly provided with coal in comparison with the other continents. A little is found in Abyssinia and British East Africa, but the rich coalfields of the continent are south of the Zambezi, in British territory. Large deposits of good coal occur in Rhodesia, the Transvaal, and the Orange River Colony. Good bunker coal is obtained from Newcastle and Dundee in Natal, and there are also deposits in Eastern Cape Colony. If, as some geologists think, these are parts of a single great coalfield, the potential resources of South Africa are considerable.

Coalfields in the New World. Coal is very unequally distributed in the New World. In South America it occurs in parts of Venezuela, Southern Brazil, Uruguay, Argentina—including Southern Patagonia and Tierra del Fuego—Chile, and Peru, but not to any great extent. The output of Chile, though increasing, is not yet large.

The coalfields of North America vie with those of Eastern Asia in extent and value.

Rich coalfields are worked in Nova Scotia in the east and in Vancouver Island in the west of Canada, the Nanaimo mines of the latter yielding the only good coal of the Western Pacific shores. In the interior, coal occurs from Manitoba westwards, especially in the Rocky Mountains, but owing to the lack of communications and population only a fraction is worked. The coalfield west of the Crow's Nest Pass, now reached by the railway, is said to be one of the most extensive deposits in the world. Large deposits of lignite are found in Alberta. Unfortunately, Eastern Canada, the most densely populated part, is destitute of coal, and imports much from the United States, Buffalo being the chief lake port.

Coal in the United States. The United States ranks first among the coal-producing countries of the world, with an output in 1912 of 477,000,000 tons, valued at nearly £145,000,000. Coal is said to underlie about one-sixth of the country, but estimates of the total area of the coalfields vary considerably. Those of the late Professor Rogers made it about 197,000 sq. miles, but the later estimates of Professor Hitchcock raise it to nearly 230,000 sq. miles. Other estimates put it at a still higher figure. The figures given below are those of Professor Hitchcock. Bituminous coal is mined in twenty-five States, Pennsylvania, Illinois, Western Virginia, and Ohio coming first. Much coal is locally used, especially in the busy region round the Upper Ohio.

The coalfields of the United States are (1) the Appalachian field, extending from New York to Alabama, a distance of 900 miles, through the States of Pennsylvania, Maryland, West Virginia, Ohio, East Kentucky, Tennessee, Georgia, and Alabama. In West Virginia the thickness of coal is about 50 ft. The total area of the coalfield is over 63,000 sq. miles. The coal is often exposed in the deeply cut mountain valleys, so that it can be easily and cheaply worked. The numerous rivers transport it cheaply to the towns and industrial centres. Its combination with iron in Western Pennsylvania has created the great iron industries which centre round Pittsburg. In this region, and especially at Connellsville, is made three-quarters of the coke of the United States, used chiefly in the pig-iron industry. The output of Pennsylvania is about 143,000,000 tons of bituminous coal. New York ranks next to London as a coal market.

The Central Coal Basin, east of the Mississippi, in the States of Illinois, Indiana, and Western Kentucky, is over 51,000 sq. miles in extent, with a maximum of 30 ft. of coal. The northern or Michigan basin is small, under 7000 sq. miles, with a maximum of 11 ft. of coal. West of the Mississippi is the vast West Central or Missouri coalfield, with an area of over 100,000 sq. miles, in the States extending from Iowa to Texas, and including parts of Nebraska, Missouri, Arkansas, and Indian Territory. Much of the Texas coal, however, is poor in quality. There is also coal in parts of the Rocky Mountains and in parts of the Pacific coast.

A Vast Deposit of Anthracite. Pennsylvania also leads in the production of anthracite, turning out about 75,000,000 tons a year. The deposit area of anthracite, Susquehanna, Lehigh, and the Schuylkill valleys of Eastern Pennsylvania, is estimated at about 450 sq. miles. A species of anthracite, resembling graphite and very difficult of combustion, is found in the New England basin, estimated at 750 sq. miles in area. Small deposits are also found in Colorado and New Mexico. Lignite is abundant in the western part of the Central Plain and round the Gulf of Mexico.

Most of the United States coal is absorbed by the home market, though increasing quantities are exported to Canada, the West Indies, Central and South America.

In Mexico coal is found in several parts, but at a height of from 2000 to 4000 ft. above the sea. There is also some coal in Central America and the West Indies.

The world's output of coal thus now amounts to over 1,229,000,000 tons a year, of which the British Empire supplies about one-fourth.

Petroleum. Petroleum is a liquid mineral product, stored in subterranean reservoirs. These are generally reached by boring, but there are also "gushers," or free-flowing wells, yielding many thousands of gallons daily, much of which runs to waste before storage apparatus can be erected. The crude oil is usually carried in pipes to the centres from which it is distributed, refined or unrefined, as the case may be, by pumping it into tank cars or tank steamers.

Petroleum is widely distributed. It is found in Germany, Galicia, Rumania, and on a vast scale in Southern Russia, in Transcaucasia. Valuable deposits are found in Persia, and now furnish supplies to the British Navy. The petroleum of the oilfields of Burma is carried by pipes to Rangoon, for the Indian market. The line of deposits is continued in the islands of the Eastern Archipelago (Java, Sumatra, Borneo, the Philippines), near Sydney, in New South Wales, and in New Zealand. Africa has workable deposits in Algeria and Cape Colony. The oilfields of North America vie with those of Russia. Those of South America (Peru, Venezuela, Argentina) are less considerable.

Baku, on the Caspian Sea, is the chief centre of the Russian oil industry, which in 1912 produced nearly 2856 million gallons, forming one-fifth of the world's total production. Much of the output goes across the Caspian to Astrakhan and the Volga for the European markets. Some is distributed through Batum and Poti, on the Black Sea. The restriction on sending oil in bulk through the Suez Canal is now removed, and Port Said is the depot for the Eastern market.

Petroleum in the New World. The United States furnishes over three-fifths of the world's total supplies; in 1912 the production amounted to over 9000 million gallons, valued at £32,000,000. The first boring for petroleum in the United States was made in Pennsylvania in 1859. The product was refined round Pittsburg and Oil City. This region is still very productive, with 20,000 wells and several thousand miles of pipes leading to the refining and exporting centres on the Great Lakes and the Atlantic coast. California alone produces two-fifths of the total output, and along with Oklahoma and Illinois supplies 75 per cent. The production of Oklahoma has increased from 50,000 gallons in 1901 to over 2000 million gallons in 1912.

THE GREAT ABYSS IN WHICH DIAMONDS LIE

ONE OF THE MOST PRECIOUS MINERAL SOURCES OF THE WORLD—A GREAT DIAMOND MINE AT KIMBERLEY

The distillation of petroleum is said to yield 200 different products which are widely used in the industrial arts. The lighter oils, known in the United States as kerosene, are used for lighting, the heavier (American paraffin) for heating and lubricating machinery. Oil fuel for steamers and trains, already used to some extent, has probably a great future. Other products, all highly inflammable, are naphtha, gasolene or petrol, benzene, benzoline, and rhigoline, the latter used to cause local anæsthesia by rapid evaporation. The residuum yields paraffin and vaseline. The former is used in making candles and to insulate electric wires. Ozokerit, a very similar substance of natural origin, found in Galacia and Utah, is put to the same uses British paraffin oil and paraffin wax are distilled from bituminous shale near Edinburgh. Similar shales are worked in New South Wales and Queensland.

Natural gas occurs in many parts of the United States, but is commercially important only in West Virginia, Pennsylvania, Oklahoma, and Ohio, where it is carried by pipes to the industrial centres. It has special advantages in glassmaking, which has become important in Western Pennsylvania.

Asphalt, used in street paving, can be obtained from petroleum, but its commercial sources are the natural deposits in Barbados, Trinidad, Venezuela, Algeria, the Swiss Jura (Val de Travers), and other parts of Europe.

Iron and Steel. Iron ranks next to coal in commercial importance. Directly or indirectly, it is used in nearly all industrial undertakings, so that the material condition of a country can be roughly estimated by the annual consumption of iron. In the United Kingdom and the United States it amounts to about 300 lb. per head of the population, against less than 3 lb. in India. Iron is said to occur pure in Greenland, but elsewhere it is mixed with carbon, sulphur, phosphorus, and other impurities. [See METALS AND MINERALS.] The principal iron ores are (1) the black oxide or magnetic iron of Sweden, the Urals, Canada, and the United States; (2) the red or brown hæmatites of Northern Spain, Elba, France, Germany, and the British Isles. In England there are deposits 15, 30, or 60 ft. thick in the Furness district. The purer carbonates of iron are known as spathic ore, the less pure as clay ironstone and blackband ores. The Eisenerz district of Styria is the chief source of spathic ore. Some spathic ores are rich in manganese, which plays an important part in the Bessemer process. [See below.] The clay and blackband ores are very common in Britain. The sulphides, or iron pyrites, are valuable only for the sulphur they contain, a minute percentage of sulphur being extremely injurious in iron.

The Supply of Iron. Iron is very widely distributed over the world, but the United States, the United Kingdom, and Spain are the chief sources. The best ores are those of Canada, Lake Superior, Sweden, and Algeria. The chief ironfields of Britain are in the Scottish coalfield; on the Cumberland coalfield, including the Furness district of Lancashire; round the Tyne and Tees, including the Cleveland district of North Yorkshire; on the Yorkshire coalfield, especially round Sheffield; in many parts of the Central Plain, especially on the coalfields, and on the South Wales and Bristol coalfields. [See map, page 820.]

In the United States the Northern Appalachian region (Pennsylvania and New York) has in recent years been passed by the Lake Superior region (Minnesota, Michigan), which produces four-fifths of the total, and by the Southern Appalachian (Birmingham, Ala.).

Iron occurs either at the surface or at considerable depths. The Bell Island mines of Newfoundland are really an open quarry of red hæmatite. Some of the famous iron ores of Lake Superior can be extracted by steam-shovels, the daily output of each shovel being from 1500 to 2000 tons.

Iron enters into commerce as pig iron, cast iron, wrought iron, and steel.

Iron Smelting. To remove impurities, iron must be smelted. Before the use of coal, the fuel was charcoal, but only very pure ores could be used. The iron industry was then confined to forested dstricts such as the Forest of Dean, in this country, or the Weald, which was gradually deforested by the ironworkers. The black oxide occurs in rocks in which coal is very seldom found, and these ores are still smelted with charcoal in Sweden and Russia—both forest countries. The process is much dearer, but a much better result is obtained. With the introduction of coal fuel the iron manufacture shifted to the coalfields. In our own country, coal and iron generally occur together. This is one of our great commercial advantages. Where they do not occur together it is more economical to carry the ore to the fuel, for the equivalent of two tons of coal is needed to turn out one ton of steel. This is profitable only where water transport is available, as in the case of Lake Superior, Sweden, and Northern Spain. Where long railway freights would be incurred, as with the rich iron deposits of the Rockies, iron, however abundant, is commercially of little value.

Coke, which is relatively free from sulphur, petroleum, or natural gas, is also largely used in iron smelting.

To extract iron from the ore the latter is smelted, or melted, by intense heat, in blast furnaces with forced draught. The largest furnaces in this country are round Middlesbrough, the centre of the Cleveland district.

Where coal, iron, and limestone occur together, a district is ideally situated for iron smelting. This is the case in the coalfields of the Pennines, in this country, and in the Birmingham district of the Southern Appalachians.

The World's Production of Iron. The total quantity of ore today extracted exceeds 150,000,000 tons, valued at over £42,000,000. The United States turn out over 56,000,000 tons, or over one-third; Germany (with Luxemburg), nearly 30,000,000 tons, or one-fifth; and the United Kingdom, over 15,500,000 tons, or one-tenth. France yields 18,000,000 tons, Spain produces 9,000,000 tons, Russia over 8,000,000 tons, Sweden 6,500,000 tons, and Austria-Hungary 4,500,000 tons. Cuba has an output of nearly 1,500,000 tons.

The world's production of pig iron is about 72,000,000 tons, the United States leading with 29,000,000 tons in 1912, or two-fifths; Germany produces 17,500,000 tons; Great Britain, 8,750,000 tons. Half a century ago the United States produced only half a million tons, and this country only 2,225,000 tons.

Wrought iron, which is malleable, ductile, and very flexible, is made by stirring or "puddling" molten pig iron in contact with the air to burn out the carbon.

Steel. Steel is a form of iron in which the small proportion of carbon required seems to enter into chemical combination with the iron instead of being present as an impurity. Steel is harder and stronger than iron, and finer in grain.

For ordinary purposes steel is made by one of three processes—the Bessemer process, the Siemens-Martin or open-hearth process, and the basic process [see METALS AND MINERALS]. When phosphorus is present in the ore, the basic process is used, lime being introduced to combine with the phosphorus. This discovery allows the Cleveland ores to be made into steel, and has greatly increased the prosperity of Middlesbrough.

The World's Output of Steel. The world's output of steel exceeds 72,000,000 tons, of which over 31,000,000 tons are made in the United States, over 17,000,000 tons in Germany, and nearly 7,000,000 tons in this country. In the United States the steel industry, formerly carried on almost exclusively at Pittsburg, is now extending north to the southern shores of Lakes Erie and Michigan, where the ores of Lake Superior meet the coal of Ohio and Illinois, and to the Birmingham region of the Southern Appalachians.

Fifty years ago, when iron rails were used, only light engines of 25 to 35 tons could be used, and traffic was proportionately slow. Modern engines, running on steel rails, are three or four times as heavy. Steam boilers resist four times more pressure than the old iron ones, so that speed is accelerated while fuel is economised. This has led to an enormous development of railway and steamer traffic, and, generally speaking, to an all-round cheapening of commodities. Great engineering works, such as the Forth Bridge or the bridge across the Zambesi gorge, have been rendered possible. Steel is even replacing timber in the framework of modern buildings, especially in the sky-scrapers of the United States.

Gold and Silver. Gold and silver play an important part in the commerce of the world by serving as the basis of the currency. They have also many uses in the industrial and decorative arts. Both gold and silver are very widely distributed, but many deposits would not pay working expenses. Gold is found in quartz or other rock veins, either pure or in combination. The rock has to be mined, crushed, and chemically treated [see MINING and METALS AND MINERALS]. In many regions gold-bearing rocks have weathered, and gold is carried down by the streams, from whose sediment it can be extracted by washing, the lighter matters draining away and the heavier gold remaining. Roughly done, this process (placer mining) is wasteful, and it is now generally carried out on a large sale by hydraulic apparatus, and the use of mercury, which forms an amalgam with the gold.

GOLD-MINERS AT WORK IN AN UNDERGROUND MINE IN SOUTH AFRICA

The discovery of rich placer deposits in the Californian Sierras in 1848 led to a "gold rush." Similar outbreaks of "gold fever" followed the discoveries of placer gold in Australia in the 'fifties, and in the Klondyke in the 'nineties.

The world's output of gold has been increased in the last half-century by these and other discoveries, and by improved methods of extraction. In 1912 it was estimated at 22,500,000 fine oz., valued at £95,750,000. The Transvaal, where the richest auriferous district is the Rand, near Johannesburg, produced £37,000,000. The United States yielded over £18,000,000, Australia £10,000,000, and Russia £6,000,000. Mexico, Canada, and India rank next. Of the total production three-fifths comes from the British Empire. The import of bullion and specie to this country exceeds £52,000,000, of which South Africa supplies over 70 per cent.

Most of the civilised countries of the world take gold as the standard of value and the basis of the

currency. Owing to its extreme softness, it is mixed with silver, iron, copper, or other alloy to give it sufficient hardness. Gold is also largely used in the decorative arts, and is put to some industrial purposes (photography, dentistry). Gold-leaf is made by beating out a given quantity of gold till its thickness is inappreciable.

Silver. Silver is generally found in combination with other elements, and very commonly with lead. The whole of the Pacific of North America is argentiferous, Mexico, the United States, and Bolivia leading as silver-producing countries. Mexico produces over 70,000,000 oz. The United States exceeds 63,000,000 oz. Canada yields over 31,000,000 oz., or about eight times the output at the beginning of the century. Australia produces nearly 15,000,000 oz. The total output of the world is over 224,000,000 oz., valued at over £28,000,000. The value of silver has fallen rapidly in recent years, being less than 1s. 10d. an ounce in 1902. It has since gradually risen, and stands today at about 2s. 4d. an ounce.

Silver forms part of the currency of gold-standard countries, and the entire currency of many others. It is used in making plate and jewellery, in other decorative arts, in photography [see PHOTOGRAPHY], and also for electro-plating.

Copper. Copper is, after silver, the best conductor of electricity, while it is much cheaper. The demand has therefore increased enormously in recent years. Copper is found either pure, as at Lake Superior and Bolivia, or in ores, the smelting of which presents considerable difficulty, and tends to be carried on at a few noted centres. In the 'sixties, Chile was the main source of the world's copper supply, but it is now surpassed by the United States, which turns out half the world's product of 1,000,000 tons (1912). The output of the United States in 1912 was valued at £41,000,000. The most important deposits, besides those of Lake Superior, are in the Rockies. These are continued in Mexico and in the Andean countries—Chile, Peru, Argentina, Bolivia. In Europe, the chief mines are in the Iberian Peninsula, especially in the Rio Tinto, and in the Harz. Japan is now one of the principal copper-producing countries. The value of copper produced in Australia in 1912 exceeded £3,000,000. The chief smelting centres in this country are at Swansea, Widnes, and Glasgow.

Copper is chiefly used for electrical apparatus, for sheathing ship-plates, and in the manufacture of brass, bronze, and bell-metal. The increasing demand is leading to a rise of prices and rumours of a future copper famine.

Lead. Lead is seldom found pure. It generally occurs in the form of galena, which contains a proportion of silver. In Europe, Spain and Germany are the chief sources of supply. In the New World, lead is found in the Rockies, including Mexico, and in Peru and Chile in South America. The United States produces 30 per cent. of the world's output, which in 1912 amounted to 1,140,000 tons; Australia yields one-tenth of the total. It is in increasing demand for plumbing, roofing, the manufacture of shot and type-metal, and for the manufacture of solder, pewter, Britannia metal, etc. Red and white lead are largely used in the manufacture of paints. The United Kingdom and the United States take more than half of the world's supply of lead, the output of Mexico going to the latter, that of Spain to the former. Great Britain has the largest import and export trade in lead in the world.

Mercury. Mercury, or quicksilver, is a liquid metal, used in making scientific instruments, such as the thermometer and barometer, in gold-mining and medicine. The most famous mines in Europe are those of Almaden, in the Sierra Morena (Spain), Indria, in Carniola (Austria-Hungary), and Northern Italy. In California are the rich mines of New Almaden. Large quantities of mercury are exported from San Francisco to the mines of Mexico and Central and South America. The output at present is 4000 tons, of which Spain supplies nearly 30 per cent, Italy nearly 25 per cent., and Austria-Hungary and the United States each 18 per cent.

Tin and Zinc. Tin, though widely distributed, seldom occurs in paying quantities. The mines of Cornwall, the richest in Europe, no longer supply the demands of the home market. At present the chief sources of supply are the Malay Peninsula, and the islands of Banka and Billiton in the Dutch East Indies. Tin also occurs in Australia, and is exported in some quantity from Tasmania. Bolivia is the chief exporting country in the New World. Tin is chiefly used to coat thin sheets of iron (tinplate), from which tinware is made. The South Wales coalfield is largely engaged in the tinplate trade. Tin is also used in making bronze, pewter, and Britannia metal. Zinc is found in various parts of the United Kingdom, but Prussia and Belgium are the chief sources in Europe. In the United States it occurs in the States of Kansas and Missouri and in Alaska. It is largely used in making galvanised iron, so extensively used for roofs.

Other Metals and Minerals. The other metals of commercial value are aluminium, obtained by electric processes from bauxite and cryolite. Aluminium works are commonly near falls (Niagara, the Swiss valleys, the Falls of Foyers, in Inverness shire), which supply the needful power. For antimony, arsenic, bismuth, chromium, cobalt, manganese, nickel, and platinum, and their uses, see METALS AND MINERALS.

Many other commodities belonging to this class might be mentioned if space permitted. Sulphur, used in making gunpowder and matches, in the vulcanisation of indiarubber, and for many other purposes, is obtained either from volcanic districts or from iron pyrites. Plumbago (graphite, blacklead) is chiefly obtained from Ceylon. Nitrate of soda, a valuable agricultural fertiliser, is worked in the deserts of Northern Chile. Salt is found in many parts, either as rock salt or brine springs. It is also obtained by evaporating sea water.

Marble is the most valuable of many building stones. Lithographic stones are obtained from Bohemia. Kaolin, a decomposed granite which derives its name from the Kaoling Mountains of the Chinese province of Kiang-si, is used in making pottery and paper. It is found in Cornwall, France, Germany, and the United States.

Precious Stones. Nearly the whole of the world's diamond supply comes from South Africa. Brazil supplies only a fraction, and those of inferior quality. Pearls and mother-of-pearl are obtained from the Persian Gulf, Ceylon, the seas round Australia, and Venezuela. Rubies come chiefly from Burma and Siam. Sapphires are exported from Ceylon, Kashmir, Burma, and Queensland. Opals come from Hungary, Mexico, Colorado, New South Wales, and Queensland. Coral, produced by the coral polyp, is fished in various parts of the Mediterranean [see page 3635].

A. J. AND F. D. HERBERTSON

THE DOME UNDER WHICH NAPOLEON LIES

AN ARCHITECTURAL MASTERPIECE—THE DOME OF THE INVALIDES, PARIS

FACING PAGE 6433

The Preparation of Specifications and Estimates. Tenders. Contracts. Supervision of Work. Certificates. Training and Qualifications.

THE EDUCATION OF AN ARCHITECT

THE architect occupies a different position from many other artists, in that he does not, with his own hands, create the works that he produces. In the case of the painter or sculptor, though he may be assisted in certain parts of the work, his artistic creations are due directly to his own craftsmanship. In the case of the architect, though he makes drawings, they are only a means to an end, and the actual achievement is the completed building; and for the carrying out of the building he must call in the assistance of many workmen whose operations in the various building trades have been already described in detail.

His work, moreover, besides having artistic excellence, must usually be designed with a view to giving definite accommodation of some kind or other, and its success will depend not only on its beauty, but in most cases on its utility and convenience. The completion of the work will involve the expenditure of a more or less large sum of money, provided by his client, and for the judicious application of which the architect is responsible. It is necessary, therefore, that he should have a sound knowledge of construction and materials, and at least a fair grasp of business methods.

The Architect Always a Student. The previous chapters have dealt with drawings, which are the principal medium for expressing the architect's intentions; the present deals with some of the more important matters that he has to deal with in his practice, and concludes with some account of an architect's technical education and the present facilities for obtaining it. But it should be pointed out that the architect should remain a student throughout his whole career. New methods of construction are introduced from time to time; new opportunities for studying existing works of merit will be offered as his business takes him to and fro in the country, and possibly abroad, and he will be constantly in a position to acquire new information. A sketchbook and notebook, therefore, should be his constant and life-long companions.

Acquiring Experience. It may be well to point out to the young student, about to enter in practice for himself, that there is much to be learnt besides drawing before a man can become fully qualified to deal with the various problems that inevitably arise when the actual execution of a building begins. Much of this knowledge cannot be taught in any school; much of it may be acquired in the office of a good architect, and it is probably more easily acquired in an office of moderate size than in a very large one; some of it can only be acquired in the school of experience.

The young architect will have to carry out his early work with more labour and trouble than his later work. He will generally have more time at his disposal to give to it and the careful working out of his general and detail drawings, and the preparation of his specification will be well repaid, first, if the work is well done, by the satisfactory result of the completed building; and secondly, by the experience gained and the facility that each carefully studied bit of work tends to give.

Specifications. Next in importance to the architect's drawings, and in a large measure supplementing them, is the *specification*. This is a written description of the work, dealing in detail with the operations of each individual trade employed in the building. It forms, with the drawings, an expression of the architect's instructions to the contractor and his workmen, and is useful for describing materials, methods of work, and so on, which cannot be expressed in the drawings. It should be clear, as concise as possible, and care should be taken to see that it does not contradict the drawings. The young architect should write his own specification, and will learn much in the process, for it describes work in detail, and he must be clear in his own mind as to his intentions before he can properly specify any piece of work.

It should be precise, and all vague terms, like "of good quality," should be avoided, a definite quality or money value being stated wherever possible. It may be useful to take a specification for a similar building as a model, so far as general arrangement of trades, customary phraseology, and the detailing of works in each trade are concerned, but it is dangerous to transfer bodily into a new specification portions of the old, unless it is quite clear that they fully apply to the new work.

In the pressure under which modern work has often to be conducted, it is very usual for the quantity surveyor to write the specification as the quantities are taken off. If this is done, the architect should supply very full notes as to materials, and as much as possible in the way of detail drawings. This method is most successful when the surveyor has worked with the architect on other buildings, and, at any rate, assures that the specification and quantities will agree. The danger is that the surveyor in some matters may not express exactly the architect's intentions, and the architect should carefully read it through after completion. Except in London, it is quite usual for the architect to take out the quantities for his own work, and in such cases he will of necessity also write the specification.

Approximate Estimates. One of the difficulties that confronts the young architect especially is that of providing his client with an estimate of the probable cost of the building. It is often necessary that such an estimate should be given in quite the early days of preparing a design, and that it should be reliable. This is one of the matters which requires experience, but to some extent the experience of others may be of service in some methods of estimating.

For example, with certain types of buildings, the accommodation of which is more or less standardised, it is possible, even without plans, to give a fairly reliable estimate, based on the cost per person. In a hospital, for example, so much per bed, in a church or school, so much per sitting, may be taken as a basis of cost; but even in such rough estimates judgment and experience are necessary in selecting the price which is the basis of the estimate, as there will be very wide range in cost between the cheapest and most expensive buildings of the same class.

Estimate by Cubing. A very usual method is known as *cubing*. This consists in calculating the actual cubical contents of the building. Measurements are taken to the outside of all walls horizontally, and vertically from the top of the footings of the building to half-way up all inclined roofs and to the parapets of flats, allowance being made for any special features rising above this level. Some architects measure the height from the level of the lowest floor; either method is satisfactory provided it is used uniformly for all buildings. The cubical contents being ascertained, the cost of erecting the building, assuming it could be built for one penny per foot cube, is calculated, and finally this sum is multiplied by a figure which experience has proved to be the cost per foot cube of erecting similar buildings. The value of the estimate will depend on this figure being properly fixed, due allowance being given for circumstances, particularly favourable or the reverse; and as the cost per foot cube for different classes of buildings may range between twopence and half-a-crown, or even more, it is easy to see that great care is necessary, and a record should be kept of the cubical contents of all buildings erected by himself, and when possible, by others also.

Caution against Under-estimating. A more exact method, but one involving some expense, is to have the quantities for the general carcase work taken out by the surveyor and priced, and then a percentage added for the finishing trades; this will often give very accurate results. It is, however, fair to say that estimating, however carefully done, has some amount of uncertainty attached to it; for even when quantities are taken out and priced in detail by different builders, it is considered very good estimating if the difference between the highest and lowest tender does not exceed 10 to 15 per cent., and it is by no means unusual for this difference to be as much as 50 per cent., and even more.

The inexperienced architect should resist the temptation of under-estimating; for should his estimate be considerably exceeded by the lowest tender, it is sure to lead to unpleasantness, and possibly to the abandonment of the work.

Quantities. When definite estimates from builders are required, it is generally necessary that *bills of quantities* should be prepared. It was formerly much more the custom than it is now for builders to make their estimates from drawings and specifications, even for important works. Estimates are still prepared in this way for minor works, alterations, and for decorative work in which builders are not put in competition with others, or where not more than three estimates are invited, but for work of importance, in which estimates from several builders are required, quantities are considered essential; and it has been held that instructions to an architect to obtain estimates imply the employment of a surveyor to take out quantities. It is best, however, to obtain definite instructions from the client for his employment, as the payment of his fees is a charge upon him, even though, in the event of a tender being accepted, it is paid by the builder, for the amount of such fees is a "provision" included in the bills. The surveyor's fees are charged by commission on the value of the work, the maximum charge being 2½ per cent., but in plain work, and for work in which there is much repetition, a lower fee may be reasonable, but should be the subject of a definite arrangement. Quantity Surveying is dealt with in detail in a later chapter.

Bills of Quantities. Briefly, *bills of quantities* consist of a summarised statement of the whole quantity of the work in a building, divided into trades. The amount of brickwork, for example, is measured from the drawings and reduced to a definite number of rods, and any special work or labour is dealt with separately. The work in each trade is thus dealt with by the process known as *taking off*—that is, by measuring from the drawings, and *billing*, which is collecting the various items and tabulating them in bills; any special work or features that cannot be dealt with by measuring, such as the setting of a stove in a fireplace, is made the subject of a *provision*—that is, the builder is directed to allow a definite sum for the work, in which case the work done is actually measured or accounted for as daywork on completion, and adjusted with the provision, or is the subject of an *allowance*, in which case the nature of the work is indicated, and the builder inserts a sum which he considers will suffice to meet it. In this case he can neither claim an extra nor be required to account for a surplus. Provision should in either case be made for deducting the full amount if the work is not carried out.

When the bills are completed, a copy is issued to each builder who is to give an estimate, and he charges against each item in the bill the price which his experience suggests as sufficient to cover the cost—in the case above cited, the cost of executing a rod of plain brickwork, which, multiplied by the number of rods, will give the total cost of the plain brickwork. Each item is similarly priced and worked out, and the total cost of all the items in each trade is added up, and finally all the trades are collected and totalled. Some builders, in costing, allow for their profit and management expenses in pricing the details; others price them at prime cost, and add a percentage to the gross total when it is ascertained.

When a tender is accepted, the builder is required to deposit with the architect a copy of the quantities, fully priced out and verified. This may be sealed, and is used as the basis for adjusting the values of any variations due to omissions and extra work upon the completion of the building.

Tenders. When such estimates are required from several builders there are two methods of obtaining them. The first is by public advertisement, the competition being thrown open to any builder who desires the opportunity of carrying out the work. This is the usual method for all work of a public character, and is often used for work done for private clients, especially where it is desired to obtain the lowest possible price for the work. In the second case a limited number of builders known to the architect or to the client are invited to submit tenders—that is, offers to execute the work for a definite sum. When this course is adopted, the builders having been selected, it is held that the builder submitting the lowest tender has a strong claim to receive the contract if the work is carried out. There is not the same claim in advertised work, as it will be necessary, when the builder is not known to architect or client, to investigate his position and business standing, and there may in some cases be good grounds for passing over some of the lower tenders. Whether an invitation is private or public, the client's interests should be protected by inserting in it the following clause: "The owner (or my client) does not bind himself to accept the lowest or any tender, or to pay the cost of preparing any estimate."

It is usual that the tender should include a list of the rates per hour to be charged for the various

tradesmen who are liable to be employed upon the work, for any work that has to be executed as day-work; but no work should be allowed to be charged as daywork that can be properly measured. These prices include builder's profit and usually general foreman's time in supervision.

Contracts. A legal contract is created by a letter from the architect, on his client's instructions, to a builder accepting his tender. After acceptance such a tender cannot be withdrawn, and, on the other hand, if the work is afterwards abandoned, the builder may have a claim for damages. For small works a good contract is created by adding at the close of the specification such a clause as the following: "I undertake to execute the above works under the above conditions for the sum of £——." (Signed) Builder. "Accepted." (Signed) Owner.

The drawings should also be signed, all documents dated, and the contract specification should be stamped with a sixpenny stamp at the time of signing, properly cancelled or stamped at Somerset House within a fortnight.

For important works a set of conditions is required controlling the manner of carrying out the work, and regulating matters of great importance that may arise in connection with its execution. Merely as examples, the following may be cited: time of completion, method and time of payments, death of either party, disputes and arbitration. It sometimes happens that a client desires such conditions to be drawn up by his own solicitor. In that case the builder will naturally require his own solicitor to approve them before he signs the contract, and the architect will also do well to see that his interests are properly guarded. In the large majority of cases, however, it is usual to employ the "Form of Agreement and Schedule of Conditions for Building Contracts" which is issued under the sanction of the Royal Institute of British Architects, in agreement with the Institute of Builders and the National Federation of Building Trade Employers. Separate forms are provided to meet cases (1) where the quantities form part of the contract, (2) where quantities do not form part of the contract. They may be had at the offices of either of the above bodies, and may be procured by non-members as well as members. If this form is used—and it will generally be readily accepted by a builder not belonging to either body—it contains several blanks, which must be properly filled up; and if any conditions, as to payment or other matters dealt with in these conditions, have been inserted in the specification, it is important to see that there is nothing antagonistic between the two.

Supervision of Work. In the case of small works the necessary supervision will fall upon the architect and his staff, and should be of such a character as to ensure that his intentions are being carried out. The amount of actual supervision will depend greatly on the character of the work, and greatly, too, on the character of the builder and his foreman. Where experience proves these to be reliable, it lightens the burden of supervision, though it by no means obviates the necessity for it. Especially in cases where the architect does not know the builder by experience, at least some visits not previously arranged for should be paid. For most buildings of any magnitude a *clerk of works* is appointed, and it is best he should be appointed by and paid through the architect. He is the architect's representative in the job, and should spend his whole time on it. He must be experienced, tactful, sober, and thoroughly trustworthy, or he is worse than useless. A good clerk of works is of great assistance to the architect. He should furnish him with a weekly report of the state of the weather, number of men employed, materials received, drawings received and wanted, and, above all, he must exercise a constant and wise supervision over the work and materials. Any complaint made to the architect by him should be investigated; and it is desirable that the architect should, as far as is possible, support his view if he can reasonably do so, otherwise his authority may be compromised. If in any case his view has been a little bit exacting, he should be told of it privately.

As a rule, it is not desirable that he should do much drawing, though he may have to furnish particulars of work to the architect from time to time, and he should not be allowed to order any works that will mean a variation of the contract. Where a clerk of works is to be employed, the quantities provide that the builder shall furnish him with the necessary office or other accommodation, and with attendance.

Variations. These are a difficulty with which every architect has to cope. It is practically impossible, whatever foresight may be exercised, to design a building—at any rate, one that is large and complicated—without certain matters arising in the course of construction that, upon consideration, could be improved in the manner of executing them, or that may have been overlooked. The greater the care and time devoted to preparing the scheme, the fewer variations of this class will there be, but some are practically inevitable. Further, some conditions that no foresight could have foreseen may arise that will necessitate a variation in the work. This is particularly liable to happen, for instance, in connection with the foundations of a building. Finally, the client may alter his mind about some portion of the work, and require to have it differently carried out. It is usual, therefore, to provide that no variations shall invalidate the contract, and that all such variations shall be adjusted upon the completion of the work. In some cases, especially in the case of clients' variations, it may be possible to obtain from the builder an estimate of the cost of the proposed work before it is ordered, and to submit this and obtain the client's approval; and, wherever possible, this should be done. In most other cases the quantity surveyor must be called in, who measures the work that has been omitted and sets against this the additional work that has been executed. The value of the work is regulated by that of similar work in the priced bill of quantities. Very usually a sum of money—generally a definite percentage on the estimated cost of the work—is provided in the specification and quantities to meet the cost of such variations; and happy is the architect who finds that this provision suffices. More usually variations tend to form a more or less considerable addition to the contract sum, and possibly produce friction with the client, who very naturally requires justification of the necessity for the increased expenditure, which in some cases may be a real source of embarrassment to him.

It is certainly wise, especially for the young architect, to keep a close watch on variations, to avoid them as far as may be, and to be in a position to justify them fully when they are incurred, for a serious claim for variations may very readily result in the loss of a client.

Certificates. The builder is paid usually by instalments during the progress of the work, such payments being made on the architect's certificate. The granting of such certificates is usually regulated by the conditions of contract, a very common arrangement being that the builder is paid at the rate of 80 per cent. of the value of the work done, including joinery and similar work actually delivered on the building, until a sum is held in reserve equal to a settled amount, which is very usually 10 per cent. of the total value of the contract. After such reserve is reached, he is entitled to be paid for the full value of the work. On the satisfactory completion of the contract, part of the retention money is paid over, the balance being held throughout the period for which he is held responsible for making good defects of materials or workmanship. The final balance is only paid on the completion of such work.

The architect must take care to see that each certificate represents as closely as may be the proper proportion of the value of work done, and should avoid over-certifying. On the other hand, he should not keep from the builder money to which he is entitled, except for some special reason. If, for example, the builder had neglected to make good any materials or work to which the architect had objected, this may be a good reason for withholding a certificate otherwise due. In cases where the builder is known to and nominated by the client, the latter should have impressed upon him the importance of his not paying money to the builder except upon the architect's certificate.

Architects' Charges. These are not fixed by statute, and their legal sanction is that of custom. The professional practice as to the charges of architects is set forth in a schedule published by the Royal Institute of British Architects, and to be obtained at their offices. The usual remuneration for an architect's services, with certain exceptions, is a commission of 5 per cent. on the total cost of the work executed Such work is to be calculated as if carried out by a builder with new materials. This covers the necessary preliminary conferences and sketches, approximate estimate if required, the necessary general and detailed drawings and specifications in duplicate, together with one set of tracings of the drawings, and supervision, and examining and passing accounts, but not charges for measuring variations.

It does not cover services connected either with negotiations for the site or for surveying it, or for surveying and making drawings of buildings to be altered, or special services connected with such matters as party walls or rights of light, or for supplying drawings to the landlord, or for drawings supplied to local authorities, or for services connected with litigation and arbitration. For all such matters additional charges—proportionate to the trouble involved, and in some cases depending on the professional standing of the architect—are made. As a rule, out-of-pocket expenses in connection with journeys between the architect's office and the works are chargeable.

For all works of less value than £1000, for special designs for furniture, fittings, and decorative work, and for work involving alterations and additions to buildings, such a commission is not remunerative, and a higher scale depending on the circumstances is usual, but should be a matter of agreement from the beginning.

In the case of partial services where preliminary sketches and interviews only have to be covered, the charge is made in proportion to the trouble and time involved. If complete drawings and specifications are prepared, 2½ per cent. on the estimated cost may be charged; and if tenders have been arranged for and received, 3 per cent. on the lowest tender. There are two methods in general use with regard to the payment of architects. He may be paid at the rate of 5 per cent. on the amount of each certificate as given to the builder, or he may be paid one-half the amount of his commission on the signing of the contract, and the balance by instalments as the work progresses.

Where charges are made by time, the rate depends upon the architect's professional position, and to some extent upon the character of the services. The minimum charge recognised is one of three guineas a day. It is in such matters that the rate of charge that may be made by a beginner differs from the charges made by the man of established reputation. In the case of architects who have acquired a reputation in certain branches of work, charges in proportion to the special value of their services may be made.

It is not desirable that an architect should accept lower remuneration than that recognised as customary, as it amounts to underselling his professional brethren. He is entitled to make any higher charges he thinks fit, provided this is by arrangement with his client, but he could not bring an action to recover such fees and claim the custom of the profession in support of them.

The Architect's Qualifications. The architectural profession is one that calls for special qualifications and training in those who practise it. It is an open profession, the entrance to which is not protected by any system of enforced registration, and opinions in the profession are divided as to the desirability of registration; and, though some steps in this direction have been taken, for the time being, at any rate, it remains open.

A very large proportion of practising architects belong to one or other of the two principal professional bodies—the Royal Institute of British Architects, which is the older and has the larger membership, and the Society of Architects. Each of these bodies has rules governing its own members, relating to education, election to membership, professional conduct, and other matters, but it has no power to enforce them on anyone outside its own body. While membership of one or other body confers a professional status, depending on the position of the society and upon the rank of the member within it, the membership is in no way an indispensable condition of practice.

Both societies now make admission to membership, with few exceptions, dependent upon a thorough and systematic training, as tested by their own examinations. In the R.I.B.A. this was originally introduced as a voluntary test, but has gradually extended its operations, and has been made compulsory; and the training of most architectural students is arranged to lead up to the eventual passing of the examinations of one of the professional bodies. These recognise the successful passing of the examinations of certain schools as exempting their students from the earlier professional examinations.

Architecture has now received university recognition, and the Universities of London, Manchester, and Sheffield each grant a degree of B.A. honours in architecture, the effect of which is to allow the student, after passing the intermediate examination in general subjects, to specialise in architecture

THE GLORIOUS WORK OF INIGO JONES

A MASTERPIECE OF BRITISH ARCHITECTURE—KIRBY HALL, NORTHAMPTONSHIRE

for the final examination. Liverpool University grants a degree of Bachelor of Architecture. In several of the more important towns throughout Great Britain schools are established in which an architectural training is given. In practically all of them the system of instruction, while it aims primarily at preparation for the career of an architect, is so arranged as to allow of students preparing themselves for the Institute or other professional examinations.

Board of Architectural Education. The Council of the R.I.B.A. appoint this Board to deal with the education of students in architecture and to conduct the examinations. The Board recommend: (1) that intending students should in all cases produce evidence of a good general education and of some capacity in drawing; (2) that the course of training should extend over at least four years, of which the first two or three should be spent in an architectural school, and the remainder in an architect's office as pupil, improver, or assistant, the school training being continued during this period, generally by evening work.

The subjects recommended for school training are: (1) building materials; (2) construction, including (*a*) applied mechanics and mathematics in so far as they are necessary to the solution of problems of construction, and (*b*) the practical methods of the building trades; (3) architectural drawing; (4) the study of architectural forms that have been evolved in the architecture of the past out of constructional necessities, and exercises in the design of construction to meet definite problems; (5) the study of the history of architecture in so far as it illustrates and explains the evolution of architecture through constructional material and social conditions.

It is also recommended that the course should include some workshop training, preferably in the form of demonstrations given by craftsmen in the various trades in the actual materials used by the trade, and that visits should be paid to buildings in course of construction, with a view to studying the actual methods of construction on the works. It is recommended that during the period of office training courses of a more advanced character should be continued in these subjects.

The Institute examinations are at present three in number:

The Preliminary. This is to test the student's general knowledge in cases where he has no certificate on leaving school that will be evidence of such training. The fact of having passed the matriculation examination of any university in the British Empire, or certain other examinations, of which a list is given in the R.I.B.A. Calendar, exempts students from sitting in any of the subjects passed at such examination. On passing this examination he is registered as a probationer. This preliminary examination is likely to be discontinued at an early date, and students will be required to produce satisfactory evidence of a good general education in the form of a certificate of having already passed some recognised examination in general knowledge before being registered.

The Intermediate. This examination is open to a probationer of seventeen years of age, who must submit eight sheets of drawings as testimonies of the course of study he has pursued, and, if these are approved, is admitted to the examination. This corresponds to a standard such as would be obtained by a satisfactory student who had taken a two years' or three years' course at one of the universities or other schools of architecture, and the Institute recommend students in all cases where such courses are available to take them. In the case of students who have obtained satisfactory certificates at one of the universities, and at certain other schools of which a list is given in the R.I.B.A. Calendar, exemption is granted from the intermediate examination; and such students, and those who pass the examination, are registered as students of the Institute.

The Final. This examination is open to students of twenty-one years of age. Every student, with his application, is required to submit four accepted problems in design chosen from alternative problems set by the Board of Architectural Education, or other designs which may be accepted in lieu of them, together with a thesis. The examination is divided into two parts: (1) design of a building of moderate dimensions; (2) papers on construction, hygiene, building materials.

University Training. Often a university degree is first obtained before beginning the professional training. This can best be obtained in a properly organised school, and there are undoubted advantages in selecting one, where circumstances permit of a university standing.

In London the University School of Architecture at University College has been formed by amalgamating the school formerly existing at that college with the school formerly at King's College, and provides two-year and three-year courses specially adapted for students intending to take the college certificate giving exemption from the R.I.B.A. intermediate or the university degree respectively. In addition to the subjects already detailed, the course allows of students attending for a portion of their time at the Slade School for the practice of drawing from the figure and modelling, while special courses in archæology, or engineering, or in other faculties can be arranged for. Advanced work is also provided for by a course in academic design and by a course in town-planning. A complete set of demonstrations in the various building crafts is also arranged. Courses generally similar in scope are provided by the Universities of Liverpool, Manchester, and Sheffield.

Courses of Training in London. Of schools not of university standing the most important probably is that of the Architectural Association in London, which provides both day and evening instruction on the lines recommended by the Board of Architectural Education, and whose students, on satisfactorily passing a three-years' course, obtain exemption from the R.I.B.A. intermediate. Other facilities for more or less complete courses of training in London include the Architectural School of the Royal Academy of Arts (design only), the Royal College of Art, the L.C.C. School of Building, the Polytechnic, Regent Street, and other centres.

Courses in the Provinces. Outside London the facilities for training are much more widely diffused than was the case a few years ago; and a large number of the more important towns throughout Great Britain can offer some definite courses of instruction to intending students, and in some cases these are very complete and efficient. Among them may be mentioned the Technical College, Aberdeen, Birmingham Municipal School of Art, Glasgow School of Architecture, and the Leeds School of Art.

R. ELSEY SMITH

Loss Caused by Insect Pests, and how it is Combated. The Chief Pests and the Fruits they Attack. Spraying Methods and Formulæ.

ENEMIES OF THE FRUIT GROWER

With the increase in the amount of fruit grown in the country, the injurious insects and fungi have likewise increased at an alarming rate. It is, after all, only the natural sequence to the transformation that has been made in our countryside; as long as fruit is massed together in certain districts, thus providing an ample and easy living for these noxious pests, so long will they continue to thrive.

In the early days a farmer or market gardener in a certain locality would find that the small portion of land that he had under fruit cultivation was very profitable, and, naturally concluding that his land must be suitable for the production of fruit, planted more. His neighbours, seeing that he was making more money out of growing fruit than they were out of ordinary farm or garden crops, would follow his example, until the whole district gradually became entirely given over to fruit cultivation.

In those days many of the pests which now trouble the fruit-grower and lessen his profits were unknown, but as time has advanced they have become a real menace and a danger that has to be reckoned with—how great may be gathered from the fact that it has been estimated that in the United States alone the loss caused by these little enemies of the fruit-grower amounts to no less a sum than between £70,000,000 and £80,000,000 annually. In this chapter it is intended to deal with the subject in such a manner as to be of practical service to the smallholder, market gardener, and allotment holder.

As these troubles arose, it became very apparent to the practical man that something must be done, and done quickly, or else the fruit-grower would have to go out of business altogether. Men began to think and watch and study; they found that these insects existed in other forms: they found that they change their form, and that, though they might do the damage at one period of their lives, there were other periods when it was easier to attack them. This resulted in the fact being forced upon students that the life-history of these insects must be studied and worked out in order to ascertain at which period of their existence they could most easily and effectually be eradicated.

Insect Transformation. The majority of these insect pests undergo a complete change of form and appearance at different times of their life. They exist as (1) the egg; (2) the caterpillar, which is termed the larva; (3) the chrysalis, or pupa; (4) the adult, or perfect insect. In the majority of cases it is in the caterpillar stage that they do the most harm, sometimes by gnawing the roots, in other cases by attacking the fruit-buds; others enter and eat the fruit, and some devour the foliage.

Nature, when left to herself and not interfered with by man, regulates the damage done by providing natural enemies to the destroyer, one species of insect living on another, and thus maintaining the balance. It will be readily understood that insects cannot increase beyond the supply of food on which they live. In the case of some their food is vegetation; for others it is other insects.

When an insect pest has occurred in wild vegetation, there has generally appeared another insect which is parasitic on the first—that is, lives on it. If, on the other hand, the pest has not been interfered with by a parasite, it increases at a very rapid rate, and soon destroys the particular form of vegetation which is its food before the plant has seeded, thus starving itself by preventing a further growth of that variety of plant in the same neighbourhood in another season.

Let us suppose, for instance, that a field of clover has been destroyed by a certain species of insect; as the plant has been destroyed before the seed has ripened and fallen there will be no crop for the insect to feed on another year. Under modern conditions man now steps in and provides seed from another district, thereby providing food for the insects, so that, instead of being starved to death, they are able to multiply.

Under Nature's conditions, when the pest first began its depredations a parasitic insect would have been attracted to the neighbourhood because of the food supply, and have largely, if not entirely, destroyed the original insect pest, and in turn have starved itself because it had destroyed its own food supply.

Though there are certain natural enemies of the insects that cause the fruit-grower so much loss, and though these do render him a certain amount of assistance, they cannot be relied on to any extent, because the fruit-grower himself has destroyed the balance of things by providing food for his enemies to an abnormal and unnatural extent, without at the same time increasing the number of parasites. From this it will be seen that too much importance must not be placed on the assistance of the natural enemies. Nature's conditions having been interfered with, it becomes necessary to adopt artificial measures of protecting the trees from the pests.

It is of great importance to remember that the stronger and better the tree, the better able is it to resist the attacks of insect pests, and also of fungus disease, which is another form of trouble that affects fruit trees.

Remedial Measures. There are two distinct forms of remedies—*insecticides*, or insect killers; and *fungicides*, for destroying and preventing fungous growths. The methods of dealing with these enemies of the fruit-grower may be divided into four classes: (1) Contact remedies, which destroy by actual contact with the pest; (2) toxic remedies, which act by poisoning its food; (3) gas treatment, by gases or fumes given off by certain chemicals; (4) mechanical and preventive measures.

To the first class belong all the fungicides and those insecticides used against sucking insects, the principal of which are nicotine, soft-soap, lime, sulphur, and salt washes, Bordeaux mixture, and paraffin emulsion. The formulæ for the preparation of these is given on page 5450.

In the second class are those insecticides used to destroy chewing or eating insects. Among these are hellebore powder and arsenate of lead.

The third class includes carbon bisulphide,

which is injected into the soil by means of an injector [51], and such proprietory preparations as Vaporite which are dug into the ground.

The fourth class consists of such devices as grease-banding of trees, and very bright lights used at night to attract moths. The one illustrated [52] has a pan surrounding the light underneath; this contains water, which has a small quantity of paraffin floating on the surface. The bright light attracts the moths, their wings get singed, they fall into the pan underneath, and are speedily overcome by the fumes of the paraffin.

It will not be possible to mention all the insect attacks to which a fruit plantation is liable, but those described under the headings of the different fruits will be found to be the chief offenders and those against which it is most necessary to wage unceasing warfare.

APPLE FOES

Codling Moth. One of the most troublesome of the insects attacking the apple is the Codling or Codlin Moth [see page 4726]. This moth lays its little, transparent eggs in the flowers or on the newly formed fruit, where it looks like a tiny drop of dew; usually only one egg is laid on each blossom. When the caterpillar hatches out of the egg it eats its way into the inside of the apple, tunnelling through to the core, and the result is the maggoty apple. The grubs are somewhat deceptive, being sometimes creamy white and sometimes deep pink. Later they leave the fruit, and at some sheltered spot on the tree, such as under old bark, they spin a silken cocoon, where they remain sometimes the whole winter, afterwards changing to small brown pupæ and emerging as moths in the spring. As moths they are at rest in the day, and fly about in the evening and at night, and are thus among those likely to be attracted by a bright light, and caught with such devices as the lamp already mentioned. Another means of catching a number of these pests is to tie a band of hay or sacking round the trunk of the tree, near the ground. The grubs will, many of them, spin their cocoons under its shelter, and these can be collected in the winter. The most satisfactory remedy, however, and one that should not be omitted, whatever other may be tried, is to spray thoroughly with arsenate of lead paste directly the blossom has fallen, not later than a week or ten days after the flowers drop. The grub, on hatching out, will then feed on poison, and die. The spraying must be done very thoroughly to be successful, otherwise it is waste of time and money.

Winter Moth. Another troublesome little grub is the larva of the Winter Moth [see page 4726], which attacks the young sappy buds in the spring and feeds on the young shoots and leaves, and afterwards on the young fruit. It is one of the varieties of "loopers," so called from their method of locomotion. They bring their hind legs up to their front ones, forming a loop with their body; then, stretching themselves at full length, they alight on their front legs and repeat the operation. This winter moth grub is yellowish-green, with pale green lines running the length of its body on either side. It reaches an inch or more when it is fully grown. Towards the end of May the grubs presumably fall to the ground. Here they form a silken cocoon, within which they change to small brown pupæ.

About October they usually emerge as moths, the males generally preceding the females. The males have full wings—that is, two pairs. When expanded they are about an inch and a quarter across. The distinctive feature of the females is that they have scarcely any wings at all, and are certainly quite unable to fly. The colour is brown or greyish-brown. The eggs are laid around buds, in the little crevices of twigs, are pale green—afterwards changing to brick colour—and have a very thick shell.

Although it is the grub that does the actual damage, it is in the moth stage that we have the best chance of checking this pest. The female, being unable to fly, crawls up the trunks of the trees to lay its eggs. It thus provides an opportunity for its destruction. This is done by arranging some means of trapping it as it ascends the tree.

There are three methods in use—the first is a tin collar which has a sticky substance smeared on the underneath side. This fits closely round the trunk of the tree as illustrated [53]. The second method is a piece of parchment or grease-proof paper [see page 4730] tied round the trunk of the tree [54 and 55], on which a similar substance is smeared; and the third is a piece of sacking about twelve inches wide tied tightly round the bottom and again about six inches up, and then folded back, forming a double band, and open at the bottom but closed at the top [53B]. In the first two cases the moth gets stuck on the grease and is thus stopped, and in the latter case it crawls up the inner piece of sacking and reaches the folded-over top and can get no farther. In the case of this pest we can also combat it in the grub stage by spraying the trees with arsenate of lead paste when the young caterpillars are attacking the buds and leaves.

The Mottled Umber Moth [see page 4726] and March Moth, which also attack apple-trees, are very similar, and the treatment of these is the same as for the Winter Moth.

Lackey Moth. About May there may be noticed on the apple-trees silken webs woven about the leaves, and enclosing within each web, which resembles a tent [see page 4726], numerous small dark caterpillars. If these are watched it will be seen that the webs or tents are gradually enlarged until they may be as long as ten or twelve inches, the caterpillars themselves growing brilliant in colour as they grow in size, becoming bluish-grey with three orange stripes down each side. A white line appears down the back, with a black line on each side of it. They now begin to leave their tents in the daytime, returning to them at night, and when fully grown they break up their colonies altogether and wander about the foliage. These are the larvæ of the Lackey Moth, and they do much damage to both foliage and buds.

About June or July they change to dark brown pupæ, housed in loose silken cocoons, either singly or in groups. There emerge in a few weeks reddish-brown moths about an inch or rather more in wing expanse, having two transverse lines across the front wings. These moths lay their eggs in July or August in a very peculiar and noticeable manner. They can readily be seen by the careful observer, gummed closely together in bands around the twigs, sometimes as many as 200 eggs in a band, sometimes only about 50. The appearance of these bands will be seen from 56.

A good way of appreciably lessening the attack for another year is to cut away the small twigs where these eggs are and burn them. As the tents of larvæ are easily seen, it is a good plan to burn these by means of a torch. This is most effectively accomplished as they are in the trees, as any attempt to remove them will allow of the escape of many of the

caterpillars. If the best results are to be achieved, this operation should be carried out in the early morning before they have left the webs, or in the evening after they have returned. Spraying with arsenate of lead is also helpful, as in the case of the other pests already mentioned, as this poisons their food.

Woolly Aphis. The presence of Woolly Aphis is indicated by patches of a white, cottony substance in the crevices of the trees and around the roots. If these are examined, there will be found tiny insects resembling the well-known "greenfly," but of a dirty white colour and slightly larger. This is one of the most troublesome of the pests that attack the apple, and many growers have been disappointed with the results after spraying the trees most vigorously. If they had only known the reason, they would have realised that the unsatisfactory result was due to the fact that they had not got to the root of the trouble, which in this case happens to be at the root of the tree, under which the insect begins its attack beneath the ground. For this reason it is sometimes spoken of as "root louse." Here it is more or less protected owing to the difficulty of getting to the under side of the roots with a spraying fluid, but unless the pest is killed below the ground it is of little use to get rid of those on the tree, as their places will speedily be taken by those from underneath. This is one of the cases, then, where a gas treatment will be most beneficial, by exterminating the pest under the soil. It will be found that if carbon bisulphide is injected into the ground it will give off a gas that will permeate the soil and kill the insects. The upper part of the tree can then be sprayed with a paraffin emulsion wash.

51. AN INJECTOR

The damage done by woolly aphis is two-fold—it causes galls or swellings on the root, and also sucks the sap, which is the vitality of the tree, often causing a black, cankerous appearance, which spreads and kills the limb of the tree. Very often young trees refuse to develop, however much the fruit-grower may try to encourage them, and when dug up it will be found that woolly aphis is the cause, as sometimes there is no indication above ground when there may be serious trouble underneath.

Unfortunately, the insects attacking the apple are too numerous for a description of all to be given here. Some of the more common are:

LEPIDOPTERA (moths): Vapourer Moth, the Tortrices, Leaf Moths.

COLEOPTERA (beetles): Apple-blossom Weevil, Blossom Beetles, the Chafers.

HYMENOPTERA (saw-flies and wasps): Apple Saw-fly, Wasps, Leaf-cutting Bee.

HEMIPTERA (aphides and scales): Apple Sucker, Cuckoo-spit Insect, various families of Aphis.

52. LAMP FOR ATTRACTING MOTHS

PLUM FOES

The two great insect enemies of the plum are Winter Moth and the Plum Aphis. Winter Moth has already been described.

The Plum Aphis. The Plum Aphis causes the leaves to curl and sucks the life from the tree. Unfortunately, this pest seems to have increased to an alarming extent during the last few years. The aphides reproduce very rapidly, and in the course of a few days the leaves of a healthy tree may roll up and die, and if they are examined will be found covered with these aphides. Strange to say, the leaves, though dead, will often hang on the tree, causing it to have a burnt appearance. No sooner do the leaves begin to shrivel than the fruitlets begin to fall, and in the case of bad attacks, although there may have been a good show of blossom, by the end of June there will be scarcely any leaves or fruitlets on a tree.

If this pest is attacked in the early stages it can be kept within bounds so that it will do no great amount of damage. This is one of the particular instances in which a strong wash late in the winter has been found very beneficial.

The first females of the year are hatched from shiny black eggs that have been laid in the autumn. These females being viviparous—that is, producing living young—and the young having the same ability, they increase extremely rapidly throughout the summer. The first females, therefore, should be killed before they begin to reproduce. Moreover, as they have the habit of curling the leaves, it is almost impossible to touch them with a spray when they are sheltered under the leaves.

Winter Washes. It is supposed, from the beneficial results obtained from experiments conducted in winter spraying, that a heavy winter wash such as lime, sulphur, and salt, although it will not kill the egg, yet, having covered the tree, ensures that the food supply of the young aphides is cut off. The result is that they cannot live if they hatch out.

Winter washes are always advisable, not only for plums, but for other fruit trees, as they do considerable service in burning off lichens and mosses, thus leaving a clean bark, unfavourable for the harbouring of insect pests and eggs. Lime, sulphur, and salt boiled make, perhaps, a better wash than any other, as it adheres evenly to the tree, and has not that tendency to peel off in patches that a lime, sulphur, and waterglass wash has. This difference is clearly shown in the illustration of the three twigs [57].

It will be noticed in 58 that the lime, sulphur, and salt wash with which the damson orchard has been sprayed still remains evenly on the trees though they are breaking out into leaf. There are a number of commercial preparations of lime and sulphur on the market, but, owing to the necessity of straining them, they do not give the tree such a white appearance as the home-made article, which is boiled on the spot and has not been strained, other than by the strainers in the pumps as it passes through.

A very great advantage of the whitening of the trees lies in the fact that the operator can see

where he has been, and is therefore less likely to miss any part, and, also, if a careless man is doing it, slipshod work is at once apparent to his employer as well as to himself.

Red Spider. The Red Spider is one of the oldest of the pests known to the fruit-grower, and an indication of its presence on fruit-trees is that the leaves lose their brightness, gradually their

53. DEFENCE AGAINST WINTER AND MARCH MOTHS
A. tin collar; B. double piece of sacking; C. parchment or grease-proof paper

colour disappears, and they fall off. The fruit does not develop, and drops. The spider sucks the sap, and thus takes the vitality of the tree. The eggs of this pest are small, globular, red bodies, and will be noticed in the winter-time so thick on certain trees as to make the twigs look quite red.

These eggs are often mistaken for small Beetle Mites that are very often found in large quantities on the trees, and are known as *Oribatidæ*. In fact, it is almost impossible to distinguish between them with the naked eye, but every intelligent and seriously minded fruit-grower, smallholder, or allotment-holder will have his magnifying-glass or lens in his pocket. Special attention should be paid to this, as it is generally accepted that these mites at least are neutral, if not beneficial, whereas the red spider is most distinctly injurious. It may be well to mention that the mites will remain perfectly at rest when cold, and cannot be observed to move, even under the magnifying-glass, until brought into warmth. Their eggs are also very similar to the red spider, being deposited in masses on the tree-trunks, giving them the appearance of having rust or brick-dust on the bark.

Other insects attacking plum-trees are:

LEPIDOPTERA: Plum-fruit Moth, Plum Tortrix, Vapourer Moth, Codling Moth.

COLEOPTERA: Shot Borer Beetle, Plum Weevil, Green Leaf Weevil.

HYMENOPTERA: Plum leaf, Plum-fruit Saw-flies.

HEMIPTERA: Hop-Damson Aphis, Mussel-scale, Oyster-shell Bark Louse.

CHERRY-TREE PESTS

There is nothing that attacks cherries that need be singled out, as all of the following are equally troublesome:

LEPIDOPTERA: Winter Moth, Mottled Umber Moth, Lackey Moth, Cherry and Plum Tree Borer.

COLEOPTERA: The Chafers, Green Leaf Weevil, Oblong Leaf Weevil.

DIPTERA: Cherry-fruit Fly.

HYMONOPTERA: Cherry Slug Worm.

HEMIPTERA: Cuckoo Spit, Cherry Black Fly.

PEAR-TREE PESTS

The insects that trouble the pear-tree are similar to those mentioned:

LEPIDOPTERA: Winter Moth, Mottled Umber Moth, Lackey Moth, Codling Moth, Tortrix Moths.

COLEOPTERA: Apple-blossom Weevil, Fruit Bark Beetle, Leaf Weevils.

DIPTERA: Midges.

HYMENOPTERA: Apple Saw-fly, Pear Slug Worm.

HEMIPTERA: Woolly Aphis.

Social Pear Saw-fly. It may be well to draw attention to the Social Pear Saw-fly, as it makes a tent similar to that of the Lackey Moth, though the webs are usually much wider. The female saw-fly lays from thirty to sixty eggs early in July under the surface of the leaves. The larvæ hatch out in about a week, and when first hatched are straw coloured, changing afterwards to orange-yellow, having a longitudinal pale brown stripe on either side; the head is black and polished, and there are two black spots on the second segment. A peculiarity of this insect is that the pupæ will very often live in the ground through another season. This accounts for the fact, which has sometimes puzzled entomologists, that the saw-fly, plentiful one year, will disappear the next year, and reappear in numbers during the following year. After an attack by this pest it is well to give an application of gas-lime, taking care that it is well worked into the ground with a pronged hoe. Gas-lime should always be left exposed to the air for at least two months before applying it to the land, and even then it is well not to hoe it in for another two months.

STRAWBERRY FOES

Garden Swift Moth. Considerable damage is sometimes done to strawberries by the Garden Swift Moth, which, in the larva state, lives in the soil, and feeds on the roots of the plants. This moth has a flight peculiar to itself, darting swiftly backwards and forwards. Hence its name. It is a noticeable fact that the majority of moths take great care and, apparently, some amount of trouble to lay their eggs quite close to the food the larvæ particularly favour, so that the supply

54. PUTTING ON BANDS

55. APPLYING GREASE

is ready for them as soon as they are hatched, without any search being necessary on their part. In the case of this moth, however, the female just drops the eggs as it flies about at dusk, and the caterpillars, when they hatch out, enter the ground, and have to find their way to some palatable root. Fortunate indeed are those who find themselves near or in the midst of a strawberry bed,

but not so fortunate is the fruit grower, who soon discovers that his strawberry plants are suffering.

The eggs are laid in late June or July, and hatch out in little over a week and the larvæ feed all the winter until about April or May, when they pupate in the soil as brown, ridged pupæ, emerging as moths during May and June. The larvæ are dull white with brown heads, and have four hairs on each segment, and grow to 1½in. in length. They wriggle backwards very quickly when touched. As with most pests that feed in the ground, some gas treatment is of the most use in getting rid of them. Kainite, muriate of potash, gas-lime, or Vaporite are all beneficial. It is quite worth while to let fowls run over the ground, as they pick out a considerable number of the grubs.

56, BAND OF EGGS OF LACKEY MOTH

Root Eelworm. Strawberries attacked by this pest rot away from the root upwards. The eelworms—which are very tiny, about a twentieth of an inch long—infest the roots, and gradually the plant also near the surface of the soil. Reproducing with very great rapidity, they quickly cause it to rot and die, when they then spread themselves out over the surrounding soil, and attack other plants. This accounts for the fact that the strawberries seem to decay in patches. The remedies usually advocated are artificial manures to strengthen the plants sulphate of potash, or kainite. Eelworms sometimes infest stable manure and may be thus introduced to the strawberry-beds.

Ground Beetles. There are four species of beetles that damage strawberries, but all are similar in their habits. They are nocturnal, and rest in the day. They are principally found in June and July, and lay their eggs in the soil. The fact that the larvæ feed partly on slugs and insects may seem to indicate that they are beneficial rather than harmful, but as they make the strawberry fruit their chief delicacy, and feed off the ripening fruit to a very considerable extent, they must be looked upon as enemies, and not as friends, where there is a strawberry-bed to consider. They belong to the family called *Carabidæ*, which, speaking generally, are beneficial. The larvæ have three pairs of legs, hard, plated backs, large biting jaws, and on the last segment two pointed horns, with a fleshy kind of leg below. A good plan for catching the beetles is to sink pots in the ground containing meat, or sugar-and-water. Moles and hedgehogs will eat them.

Crane-flies or Daddy-longlegs. The larvæ of the Daddy-longlegs [see pages 4726–27], commonly spoken of as "leather-jackets," often attack and eat the roots of freshly planted strawberries. The appearance of these soft, dirty grey grubs is well known, but many are not familiar with their life history. The Daddy-longlegs deposit their minute black eggs in the ground, generally in grassland. From these hatch the legless maggots, which lie in the soil in a dormant state during the winter, rousing themselves in the spring to do immense damage to many crops. They vary considerably in size, sometimes attaining 1½ in. or more in length when fully grown. They are voracious feeders, and gnaw through fleshy roots, and are particularly destructive in grass and clover. They attack raspberries and loganberries as well as strawberries.

Sometimes a field of strawberries has to be replanted from this cause alone. Such was the case in Cambridgeshire a year or two ago. When fully grown they change to pupæ, in which state they do not need to feed. As soon as the hot weather begins to arrive the pupæ force themselves partly out of the ground, sticking out half of the body; their skin bursts open, and the fly emerges. They are often to be seen in the early morning of a summer day forcing themselves up through the lawns and grass meadows.

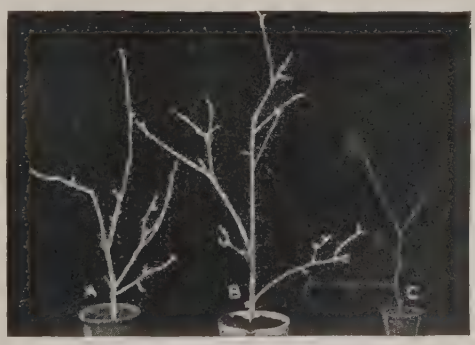
When the "leather-jackets" are in grassland the best remedy is to roll it with a heavy ring-roller in the early morning, as the pupæ are pushing their way through the ground, to crush them.

It is always best, when ploughing up old grassland, to give it a dressing with gas-lime before sowing it with any other crop or planting it with fruit, but in the case of their presence among young strawberry plants the best cure is to keep hoeing the ground, allowing fowls and young ducks to follow the men at work, when it will be noticed that they will readily devour the grubs or maggots.

Slugs and Snails. While considering insects which attack strawberries, slugs and snails must not be forgotten. These are—at any rate, to the novice—the most easily recognised of all. The best remedy is to allow ducks to wander over the strawberry beds, particularly in the early morning and in damp weather, when it will be seen that they devour them eagerly.

It may be well to point out that slugs do their damage when the fruit is ripening and the plants have been strawed, making hoeing impossible. The case is therefore different from that of the "leather-jackets." For the latter, fowls were suggested, but they will not do for the slugs, as they would be apt to scratch away the straw from the berries, but ducks do not scratch.

In the case of snails, they have a natural enemy,



57 THE EFFECT OF SPRAYING

A. with lime, sulphur, and salt; B. with lime, sulphur, and waterglass (note the wash flaking off); C. not sprayed

the common song-thrush; and, although the thrush will itself do a certain amount of damage to the crops, it more than compensates for this by the service it renders. It will take the snail in its beak, knock it again and again on a stone until the shell is broken, and then eat it with apparent relish. In this way one thrush will devour great numbers of snails.

Other insect pests of the strawberry are:

LEPIDOPTERA: Heart and Dart Moth, Strawberry-leaf Button Moth.

COLEOPTERA: Strawberry Weevil, Strawberry-fruit Weevil, Strawberry-leaf Beetle, the Chafers.

HEMIPTERA: Strawberry Aphis.

VERMES: Strawberry Eelworm (commonly known as cauliflower disease).

Strawberry Mildew. One of the greatest troubles that the strawberry-grower has to contend with is the strawberry mildew. This is a fungous disease, and has therefore no connection with any insect pest which may be present. The mildew attacks not only the foliage, but also the fruit.

The uninitiated is apt to think that it is of little importance, as it does not hinder the development of the fruit, but when he wishes to market the fruit he will learn to his cost that his crop is valueless, for it will have lost its sweetness and have a flat, insipid taste. Unscrupulous growers have been known to wash their strawberries affected with this disease in order to obtain a sale of them, but even then they present a dull, lifeless appearance, and are of no value whatever for eating or preserving.

When this fungus attacks the leaves they curl upwards, and will be seen to be covered with a white, powdery mildew which is the summer stage of the disease; this in time spreads to the fruit itself. When a garden has been attacked, the leaves should all be cut off and burned, and in the following spring, when the plants begin to grow again, they should be sprayed with sulphide of potassium or dry lime and sulphur. This latter should be dusted on to the plants, care being taken to see that the under side of the leaves is sprayed in the early morning, when the air is generally still and the leaves are saturated with dew.

RASPBERRY PESTS

The Raspberry Beetle. Everyone has come across the maggoty raspberry. The percentage of berries containing one or more of these little white grubs is very high, and raspberries are spoilt as a dessert fruit by this cause alone. Everyone, however, does not know that in the adult form these maggots are small brown beetles, about one-seventh of an inch long. They may be seen in large numbers about May and June, when the plants are in blossom, flying hither and thither with great rapidity when the sun is shining. The method that these beetles follow is to lay an egg, generally only one, in the heart of the flower. From this hatches out a little white grub within the ripening fruit. It therefore finds itself right in the midst of its food supply, and begins to feed on the berry.

It has sometimes been supposed, as two or more grubs may be found in one raspberry, that the beetle must lay more than one egg in a blossom. This is not so, however, and the fact that several grubs are found is probably accounted for by the fact that more than one beetle will visit the same bloom. Another explanation may be that the grubs crawl out of one berry and pass to another. It might be supposed that the maggots, being in the fruit and the fruit being practically all picked each season, would in that way automatically become exterminated. Unfortunately, large numbers of the grubs leave the berries which have been their host while in the egg stage, and which have perhaps not developed properly in consequence of their attack, and in travelling to another more perfect fruit fall to the ground. In this way many escape through not being picked with the fruit.

An opportunity for their destruction, however, is presented by the fact that they reach the ground, as lime and soot can be hoed into the soil and fowls may be allowed to run at will among the canes. This matter should be attended to directly the fruit has been gathered.

The grubs pupate, for the most part, in the ground, emerging in the following spring as the adult beetles. The beetles themselves have been found in the soil in Cambridgeshire as early as February 14, and in April in quite large numbers on the surface of the soil round the bottoms of the canes, although it had previously been supposed that they did not emerge from the pupæ until the beginning of May.

This seems at first sight to be contrary to Nature's usual way. The canes are not even in leaf, and certainly there are no blossoms in which the beetles can lay their eggs. Experts are still trying to find out what these very early beetles feed on, as the other plants they favour are the loganberry and buttercup, which are also dormant. There is an opportunity, therefore, for any intelligent grower to do a little research work on his own account, and perhaps make a valuable addition to what is already known of the life-history of this troublesome pest. It seems likely that there is still some habit undiscovered, as, in spite of all precautions, it appears to hold its own and is difficult to eradicate.

Spraying the canes with arsenate of lead paste when the beetles are flying about is thought to act as a deterrent to the beetles laying their eggs on the blossoms or plants. Injecting carbon bisulphide into the soil has been tried to kill the pupæ, but the damage resulting to the young spawn of the canes made the remedy worse than the disease.

The methods adopted for working out the life-history of insects varies somewhat. The cage illustrated [59] was, when photographed, actually in use among the raspberry canes for investigation work concerning the particular insect pest described above. It is made with a zinc top, finely perforated to admit rain and air; the side panels are of glass in the upper part to admit light, and finely perforated zinc in the lower part to secure a constant circulation of air. The beetles are thus enclosed so that they may be under constant observation, yet at the same time they are living under their natural conditions. In this manner the observer avoids the risk of any departure from their usual habits such as might happen if the beetles were removed.

Raspberry Moth. Another enemy of the raspberry, that in some districts does as much damage as the raspberry beetle, is the Raspberry Moth. It is sometimes known as the Red Raspberry Grub, or Stem Bud Caterpillar, from the fact that it is red in colour, and attacks the buds or terminal shoots, causing them to wither away and die. Very often, when a shoot has been attacked, Nature makes an effort to repair the loss, and two new shoots will be sent out where the previous one has died. This weakens the canes, and thereby reduces the crop.

This moth is one of the smaller moths, measuring only about $\frac{1}{4}$ in. in length; it is brown in colour with yellow spots. It may be termed a hard worker, as it flies both by day and by night at the end of May and through June. The eggs are laid on the blossoms. When they hatch out, the larvæ, which are small and pale in colour, enter the core or berry, where they remain for some little time, but they do no harm and the fruit is undamaged. Here may be noticed a peculiar or rather unusual habit. It is

not during the season that they are hatched that these grubs do their damage; they leave the fruit before it is ripe, fall or lower themselves to the ground, spin a cocoon in some sheltered spot, and there pass the whole of the winter; in the following spring they awake to new life, and feed on the young buds. They now change, first to pink and then to red, and not only make the buds their food, but

58. DAMSON ORCHARD WINTER-SPRAYED WITH LIME, SULPHUR, AND SALT

tunnel into the pith of the shoots, and finally pupate either in the pith of the cane or in the shoot. The pupa is reddish-yellow and pale pink underneath, being about ½ in. long. After three weeks or more the pupa pushes up out of its crevice, and the moth emerges.

In seeking to eradicate this pest the fact that they pass the winter as larvæ must be borne in mind. The fowls will again render us valuable service, as will also lime and soot hoed into the ground at the base of the canes. Care should always be taken, when the canes are pruned in the early winter, to burn at once all that is cut out, thus securing the destruction of any grubs that may have settled down to hibernate in the canes.

Where raspberries are grown only on a small scale, as in gardens, allotments, or even, perhaps, small holdings, it may be found possible to paint the lower part of the canes with soft-soap. This should be done in March, to catch the larvæ as they ascend the canes on their way to the buds. It will be seen, however, that this would hardly be practicable on a large scale. If a strict watch were kept to find out the time that these larvæ began feeding, the canes might be sprayed with arsenate of lead paste, which would kill them as soon as they began to eat the buds.

Chafers. The Cock Chafer, the Rose Chafer or Beetle, and the Small or Summer Chafer, all well known as devouring the foliage of many trees and plants, will often attack raspberries. As adults they eat the leaves and blossoms, but do still more damage as larvæ, in which state they live in the ground and feed on the roots for two or three years in the case of the Cock Chafer and Rose Chafer, and for one or two years in the case of the Small Chafer.

The Cock Chafer has a black head, reddish-brown wings, and brown, hairy legs. It is often 1 in. in length, is a strong, heavy beetle, and may be noticed in May or June flying about at night, and is distinguishable at some little distance by the loud humming noise characteristic of its flight. The female buries her eggs in the ground; the grubs are thick with a swollen piece at the tail end, dirty white in colour, with six jointed legs in front. They move very slowly, and appear scarcely alive when taken out of the ground, but when in their native element they move quite freely, and do immense damage by gnawing the roots, sometimes working away at the same group until the canes are completely killed. At the end of three years they make a cell, and change into pale brown papæ.

The other allied species are similar in habits. The Rose Chafer is a very pretty beetle of a brilliant green with a golden sheen, and is about two-thirds of an inch long. The Small Chafer is also about the same length, and is numerous in some districts.

Lime and soot hoed into the ground, Vaporite, and similar preparations are all useful for destroying the larvæ. In small plantations many of the adult beetles may be secured by shaking them off the canes on to tarred boards. This, however, is one of the cases in which a remedy may be adopted where fruit is grown on a small scale, which is hardly practicable where several acres are concerned.

Other raspberry pests are:

LEPIDOPTERA: Garden Swift Moth, Dot Moth.
COLEOPTERA: Raspberry Weevil, Red-legged Weevil, Ground Beetle.
HYMENOPTERA: Raspberry Emphytus or Snag Borer.
DIPTERA: Cane Gall-fly.
HEMIPTERA: Raspberry Aphis.

Loganberry. Most of the enemies of raspberries also attack loganberries.

GOOSEBERRY PESTS

Gooseberry Saw-fly. The larvæ of the Gooseberry Saw-fly are generally the culprits responsible for the number of defoliated gooseberry bushes [60] so often seen in gardens and plantations. There are as many as three broods of these hungry grubs during the summer. The first hatch out from eggs laid by the adults which appear in April or May. The females lay their eggs under the leaves,

59. FIELD BREEDING-CAGE FOR INSECT PESTS

usually along the ribs, depositing them one by one in little slits made by saw-like instruments, which give them their name. In the case of these saw-flies, the slit is very slight, and the egg is not buried in the leaf, as is the case with the eggs of others of this class. The larvæ are green, with black heads and black spots, the last two segments being yellow. When fully grown, their colour will

be found to have changed to green of different shades and the spots disappear. They are about two-thirds of an inch long when fully grown.

Saw-fly larvæ can always be distinguished by the number of legs which they possess—three pairs of true legs in front, and seven pairs of prolegs; that is, abdominal legs, the larvæ of moths having only five pairs of prolegs.

By June or thereabouts the larvæ which hatched out first begin to pupate in a dull case of silk, the majority of them in the ground, though some have been found on leaves near the surface of the ground, but not in it. The cocoons vary from almost yellow to deep brown; the pupæ are greenish-yellow.

In about ten days or a fortnight the saw-flies emerge and lay the eggs for a second brood, and these run their course, and a third batch follows. The larvæ of this last brood spend the winter in the ground, pupating in the early spring, and changing to the first adults of the year, which were mentioned as appearing in April or May.

The Gooseberry Saw-fly larvæ being very ravenous feeders, they can make great havoc among the bushes; and a vigorous effort should be made thoroughly to rid the plantation of them.

Spraying with hellebore powder wash as soon as ever the early larvæ appear is beneficial. Where gooseberries are grown only on a small scale, it is a very good plan to look over the bushes every week or ten days, from the beginning of April, and carefully to pick off the leaves where eggs are found on them. A thick coating of lime and soot on the ground, to kill the larvæ when they fall to the ground preparatory to pupating, is also of use.

Other insects which attack the gooseberry are:

LEPIDOPTERA: Magpie Moth, Currant Clear-wing, Winter Moth.

HEMIPTERA: Aphis.

MOLLUSCA: Grey Slug.

ACARINA: Red Spider.

60. GOOSEBERRY BUSH DEFOLIATED BY THE LARVÆ OF THE GOOSEBERRY SAW-FLY

American Gooseberry Mildew. In these days, when there are so many prosecutions for sending to market gooseberries tainted with mildew, gooseberry mildew must not be passed over. It is a highly destructive fungous disease which has been brought over from America, but there is a European form, which is, however, not so virulent. The grower who discovers this disease on his bushes must at once, by Act of Parliament, notify the Board of Agriculture or local authority. A thin, white mildew appears on the tips of the young shoots, generally extending backwards for a few inches only [see page 1414].

The disease appears first on the fruit during the latter part of May or early in June, in glistening spots. The appearance of the mildew soon changes, and becomes powdery, which is due to the development of the light summer spores. These spores are carried by wind and other agencies to neighbouring bushes, which thus become infected. After a time it turns to brown, and covers both shoots and berries with quite a thick mould, which can be peeled off. Towards autumn, black spots appear on this mould. These are the winter fruit of this fungus, and contain the winter spores, which germinate the following spring, and give rise once more to the thin summer mildew.

Up to the present, although much research work has been done in connection with this disease, no real cure has been found for it. There are, however, certain precautionary measures ordered by the Board of Agriculture, who have the power to enforce their regulations. All infected bushes must be tipped; that is, the branches must all be pruned back for some inches, and the prunings burnt at once. This should be done in August or early September. As a precautionary measure, spraying in May and June will be found beneficial, and is advised by the Board. The best sprays are lime and sulphur wash and Bordeaux mixture. All berries showing mould should be picked at once and burnt.

European Mildew. This is similar, but much less virulent, and very seldom attacks the fruit itself.

RED CURRANT FOES

The Currant Clear-wing. This moth does damage to black and white as well as red currants. The moth has a body half an inch long, while the wing expanse is rather less; its body is of a bluish metallic colour with yellow stripes, and ends in a fan-shaped mass of purplish-black scales; the wings are transparent, with black edges tinged with orange. The moth may be seen on the wing in June in the early hours of warm days, but later in the day it rests often on the stems of currant bushes.

The female lays her eggs on the stems, usually one on a stem near a bud. They are oval in shape, and yellowish-white in colour. A tiny white larva with a brown head soon hatches out, and begins boring into the young shoots. From this habit it is sometimes called a "currant-borer." On reaching the pith, it works its way upwards and downwards, and the shoot flags and dies. The dying off of the shoots in the summer is very often an indication of the presence of these grubs. They pupate about April, and force their way partly out of the holes the larvæ made on entering, and emerge as the moth again in early June.

In winter, little holes about one-eighth of an inch across may be detected on the shoots. There is generally a quantity of frass around the hole. These shoots should be cut back till the end of the tunnel is reached. This is all that is at present known as a check to this pest.

Other pests attacking the red currant are:

LEPIDOPTERA: Currant-fruit Moth, Winter Moth.

HYMENOPTERA: Currant and Gooseberry Saw-fly.

COLEOPTERA: Glaucous-leaf Weevil.

HEMIPTERA: Currant Scale Aphis.

BLACK CURRANT PESTS

Black Currant Gall-mite. This, known as Big Bud, is by far the most serious pest of the black currant, and is of equal importance with the

American gooseberry mildew. It was in 1896 that it was first observed to do any extensive damage; since then it has spread rapidly.

The indications of this Big Bud are the dry, brown buds, which crumble into dust when pressed, and the large-sized, swollen leaf-buds, which are caused by very minute insects, called mites, which live within the bud. They are too small to be seen by the ordinary observer with the naked eye, being only

in May, which is the period of greatest migration, though they have been noticed migrating every month except January.

The other enemies of the black currant are the same as those which attack the red currant.

SPRAYING

Many fruit-growers consider spraying useless, and hold this opinion even after they have tried it.

61. KNAPSACK SPRAYER

62. NARROW-GAUGE SPRAYER

63. DRY-POWDER SPRAYER

From photographs supplied by courtesy of the Four Oaks Spraying Machine Co.

one-hundredth of an inch long, but when placed under a lens they will be seen to have two pairs of legs in front, a ringed body with five pairs of bristles, a blunt, snout-like head, and a kind of sucker at the tail end.

When a diseased bud is opened, the mites hold on to the plant by this sucker, and wave their bodies and legs about in the air, and are able to catch hold of passing insects, such as spiders and flies. It has

This attitude is usually bred by failure, due to some error in the manner of spraying, or a similar cause.

Some insects work only on the under side of the leaves. It is obvious, therefore, that if the spray is to be effective it must be applied to the under side of the leaves. Other insects lurk within the cracks of the rough bark; in this case a spray with a good force behind it must be used if it is to penetrate to the hiding-place of the enemy. Sprays such as

64. AMERICAN PETROL-SPRAYER

65. SPRAYER FOR WORKING FROM HEADLANDS

From photographs supplied by courtesy of Mr. Matthew Herrod, Wisbech

been found that in this manner, with the aid of other insects, they accomplish journeys far beyond their own power. An infested bud sometimes opens, but very rarely gives fruit of any use.

Winter spraying with lime, sulphur, and salt, also hand-picking infested buds, has been found beneficial, but the best results have been obtained by spraying the bushes twice a week for six weeks with sulphur and soft-soap. This should be begun early

Bordeaux mixture must be applied in the form of a mist, lest they should do damage by scorching. Lime, sulphur, and salt, and winter spray, however, will of necessity need a coarse spray, because of the thickness of the liquid which has to pass.

Spraying Machines. The type of spraying machine used varies necessarily with the size of the plantation or orchard, and the way in which it is planted. A young plantation, for

instance, planted with top trees and young bushes with rows of strawberries between, is not a suitable place in which to use a horse-drawn machine, as the horse would damage the strawberry plants. Nor, although the strawberries have been taken up, could a horse be used in the same plantation with the trees and bushes grown so that their branches nearly touch, as the branches would be liable to injury.

There are a large number of spraying machines on the market, individual firms making many different varieties. The uninitiated might, therefore, be confused, and, after seeing many, might very easily choose one that would turn out to be of little use for his purpose. For instance, one of iron or tin would be useless, as the first time Bordeaux mixture was used the sulphate of copper would eat into the metal.

Knapsack Sprayers. Starting with the smallest, the knapsack pattern must be mentioned as the most suitable for use in gardens, or where in a plantation a few bushes only require treatment. It derives its name from the fact that it is used strapped on a man's back, like a knapsack. One of the best of this form of machine is that known as the "World's Cheapest" [61].

Some of the more important points of this machine are: (1) Its light weight, compared with its capacity and quality. It weighs only 14 lb., although it is made of superior quality copper several gauges stronger than most machines of this class, and its capacity is 3¼ gallons. (2) It has a large-size internal air chamber with watertight lid. (3) The spraying rod is fitted with a strainer which prevents the nozzle getting clogged. There is also a strainer through which the liquid passes when filling the machine. (4) It has a double-swivel nozzle convertible into a single. (5) All parts are interchangeable and replacements are easily effected. (6) It has been specially constructed for lime, sulphur, and salt washes.

The next in size to notice is the Herrod's Narrow Gauge [62]. This machine is made in two sizes, the large size holding 18 gallons and the small size 10 gallons. As will be seen from the illustration, it consists of a narrow tank to which is fitted a pump with two lengths of hose.

It has been pointed out that a spray, to be effectual, must be put on with a good pressure. In the case of most hand pumps there is no pressure gauge to guide the worker, who, when he has been working some time and is tired, may fancy that he is spraying with considerably more pressure than he really is; or the pump may be out of order, causing the operator to work harder and giving him the impression that the pressure is higher than it really is. On this particular pump there is a pressure gauge on the air chamber in front of the operator as he pumps, so that he can see all the time what the pressure really is. It should never drop below 80. As the sprayer only has one wheel, and its extreme width is only 12 inches, it can be used either in a young plantation where strawberries are planted between the bushes, the wheel going between the rows of strawberries, or in an older plantation where the bushes have grown close together.

There are cases when it would be hard work for a man to push a pump of this nature filled with 18 gallons of spraying wash over the ground, as, for instance, where the ground is wet and water is standing about, or when a plantation has been freshly dug. There is a pump specially adapted for such circumstances. It is known as Herrod's Demon Sprayer [65], and is operated from the headland—that is, one end of the plantation—and only the hose itself has to be taken up among the bushes. The capacity of this pump allows, if necessary, for two gallons of wash per minute to be delivered at high pressure with only one man pumping. The illustration gives a good idea of its simplicity. The pump itself is constructed on scientific principles, ensuring the greatest efficiency and least possible loss by mechanical and water friction in working. There are two delivery hose-pipes on one side of the pump, while a suction hose, which is 8 ft. long, is attached to the opposite side for sucking the spraying wash out of a tank or barrel.

A Petrol Sprayer. None of the foregoing are suitable for large plantations; large areas require a power plant for economical working. One that has deservedly received a good deal of commendation, because of its simplicity, efficiency, and compactness, is Herrod's American Petrol Sprayer [64]. Moreover, it is cheaper than many of those on the market of a similar class. As will be seen from the illustration, it is mounted on a truck and can be pulled by hand.

Power Spraying. All the machines that have been mentioned are for the use of commercial preparations, but some fruit-growers may prefer to boil their own lime, sulphur, and salt wash, and the illustration [68] shows a plant in use on one of the fruit farms of Messrs. Chivers & Sons, the well-known jam manufacturers of Histon, which is an arrangement for boiling the washes, with a triple plunger pump attached for forcing the spraying mixtures out into the orchards and plantations. The engine supplies the steam for boiling the washes and the power for driving the pump and agitators.

Powder Sprays. The appliances mentioned so far are all for wet sprays, but, as has been stated, sometimes the spray is applied in the form of a powder, as, for instance, in the case of strawberry mildew.

There are several knapsack pattern pumps for this purpose, but here again the "Four Oaks" Spraying Machine Co. has placed one on the market that has many advantages over others. It is very light and very easy working. All the working parts are visible and easily accessible, and thus simple to dismount and clean. It is quickly filled; the powder can be emptied straight into the container from the bag, no scoop being required as for the other makes, thus saving time. It also has a vaporiser jet—as far as can be learned, the only jet of its kind on the market—which distributes the powder in a very even way, and permits the flow of powder to be instantly regulated at any time. It is also the only machine that can be filled with powder, and holds twice as much as any other machine of the same size, its capacity being 18 lb. [63]. This sprayer is, naturally, only suitable for gardens or small strawberry fields.

Mr. Herrod, of Wisbech, has brought out a horse-drawn powder sprayer [69] that is eminently suitable for both strawberries and potatoes. As will be noticed from the illustration, the wheels are very high (5 ft.), with a ratchet attached, and so constructed that they are interchangeable. The hopper is large enough to hold powder sufficient for several acres. The powder is distributed by means of a fan, and is brought to the fan on two endless chains, one on either side of the hopper, thus ensuring a constant, regular, and even supply. The quantity of powder

66. SPRAYING FRUIT-TREES IN THE WINTER

67. A GENERAL VIEW OF SPRAYING OPERATIONS ON A LARGE PLANTATION

From photographs by courtesy of Messrs. Chivers & Sons, fruit-growers, Histon

blown out can be regulated from 20 to 40 lb. per acre. It is a light load for a horse, and only requires one man to work it. The powder is forced by the fan through five direct deliveries, armoured hose conducting the powder from the machine to steel tubes, which can be raised by the driver to any angle by means of a lever. At the extreme end of the steel tubing spreaders are fixed in a manner that ensures the fungicide being distributed to the under surface of the strawberry leaves or potato haulm.

Formulæ for Fungicides. The following are some of the more important fungicides:

Bordeaux Mixture. One of the best fungicides is Bordeaux mixture. The best time for spraying apple-trees for the scab is directly after the blossoms have fallen. The mixture should always be freshly made, with the following ingredients: Sulphate of copper, 4 lb.; freshly burnt quicklime, 4 lb.; soft water, 50 gallons.

Care should be taken to dissolve the sulphate of copper in about 4 gallons of water in a wooden tub; never use an iron or tin receptacle. Place the copper in a piece of sacking, and leave in the water overnight. Slake the lime in another tub, adding only a little water at a time until it is like milk; then add the rest of the water. After it has been well stirred, allow it to remain a little

68. SMALL POWER SPRAYING PLANT

while, so that it will settle; then pour off the liquid and add the solution of sulphate of copper. Finally, carefully strain. In applying it to the trees, use a very fine nozzle.

Bordeaux mixture and arsenate of lead make a very useful combined spray—that is, one that is an insecticide as well as a fungicide. The arsenate of lead is used for leaf-eating caterpillars. The Bordeaux mixture is made as already described, with the exception that only 25 gallons of water are used. To this is added 2 to 3 lb. of arsenate of lead paste that has previously been mixed with 25 gallons of water.

Liver of Sulphur. This is used for mildews, such as the summer stage of the American gooseberry mildew. The formula is: Liver of sulphur, 1 lb.; water, 32 gallons.

Nicotine. This makes a very useful wash against aphis and apple-sucker. Formula: Nicotine (95 per cent. pure), 1 lb.; water, 130 gallons.

This wash should be used just before the trees come into bloom, or while they are in blossom, as nicotine does not hurt the blossoms.

Lime, Sulphur, and Salt Wash. The formula (winter strength) is: Lime, 44 lb.; sulphur 22 lb.; salt, 12 lb.; water, 80 gallons.

The sulphur should be placed in a tub to soak for about an hour before it is required. The lime should be placed in a tank in which it can be boiled, and made into a cream by adding water. When this is made, the sulphur that has been soaking should be added, and the balance of the water, making it up to 80 gallons. It should then be brought to a boil and boiled for one hour. About ten minutes before it is finished boiling the salt should be added. The wash should then have a deep amber colour, but if it is green in appearance it has been over-boiled.

Paraffin Emulsion Wash. The formula for this wash, for use in the winter only, is: Paraffin, 8 gallons; soft-soap, 12 lb.; water, 80 gallons.

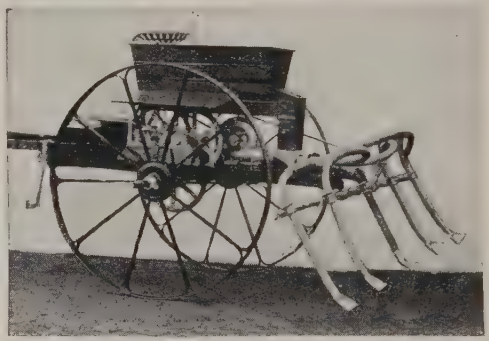
For use in the summer, the formula is: Paraffin, 4 gallons; soft-soap, 12 lb.; water, 80 gallons.

Dissolve the soap in boiling water, and, while still on the boil, add the paraffin; then thoroughly churn into a creamy liquid. These paraffin emulsion washes are used against aphis, and so on. Either Tea Rose or White Rose oils will do.

Hellebore Powder Wash. The formula is: Freshly ground hellebore powder, 2 lb.; water, 10 gallons.

Simply mix the two together, taking care that this is thoroughly done. This wash is used against all saw-fly caterpillars.

Sulphur and Soft Soap Wash. The formula



69. HERROD'S POTATO AND STRAWBERRY SPRAYER

is: Flowers of sulphur, 2 lb.; soft-soap, 25 lb.; water, 50 gallons.

Black currant bushes should be sprayed twice a week for six weeks, beginning early in May for the big bud or black currant gall mite.

Lime and Sulphur Wash. The formula for this wash is: Flowers of sulphur, 2 lb.; quicklime, 2 lb.; water, 50 gallons.

Black Currant Wash. A combination wash for black currants, when they are attacked with the black currant gall mite and winter moth, consists of: Soft-soap, 22 lb.; sulphur, 5 lb; lime, 2½ lb.; arsenate of lead, 2 lb. Boil for 1 hour.

Paraffin, Soft Soap, and Lime Wash. This wash, which is for use against woolly aphis, consists of: Paraffin, 10 lb.; soft-soap, 4 lb.; lime, 2½ lb.; water, 80 gallons.

Boil in soft water for thirty minutes. Apply to the trunks of the trees with a stiff brush, seeing that the fluid goes well into the cracks and crannies. Spray the upper part of the trees.

Carbon Bisulphide. Carbon bisulphide should be injected into the ground in ¼ oz. injections, the number varying according to the size of the trees, care being taken to see that the injections are made about two feet away from the trunks of the trees, and that the injector does not actually touch a large root.

The Principal Processes for Softening Water for Industrial Purposes. Treatment of Effluents and Waste Products from Factories and Chemical Works.

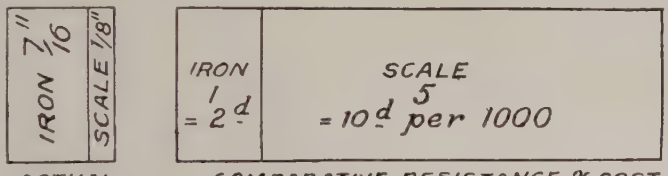
WATER SOFTENING & USE OF WASTE

Soft Waters for Domestic Use. In places where the water as ordinarily supplied is hard, and both wasteful and unpleasant to use, people would do well to remember that prevention is better than cure, and turn their attention to other and more suitable sources of supply. Why not use rain-water? A simple calculation will show that the water from the roof of a house, if caught and utilised, would be sufficient for a large proportion, and, in some cases, for the whole, of the requirements of the inhabitants. In most cases such water goes to waste.

Removal of Impurities. After a shower, the first water from the roof of a house carries with it a quantity of soot, black, birdlime, etc., which would spoil the colour of the rest, and give to it other undesirable qualities. By an ingenious contrivance, such as the Roberts Rain-water Separator [4 *A* and *B*], the dirty portion, consisting of the first washings from the roof, is automatically run to waste, and the rest, consisting of the clear and good water, is stored for domestic use. Such apparatus can be purchased for from £3 to £6. The saving to the household due to the absence of scale in kitchen boiler and kettle will quickly pay for the cost of installation. Moreover, such water is by many people much preferred for washing and for baths, and naturally the saving in soap alone amounts to something substantial per annum.

COST OF FUEL WASTE BY SCALE.

	10%	15%	20%	25%
	Cost. d.	Cost. d.	Cost. d.	Cost. d.
With coal at 8s. per ton ..	4·8	7·2	9·6	12
" " 10s. " ..	6·0	9·0	12·0	15
" " 12s. " ..	7·2	10·8	14·3	18
" " 14s. " ..	8·4	12·6	16·8	21
" " 16s. " ..	9·8	14·4	19·2	24
" " 18s. " ..	10·8	16·2	21·6	27
" " 20s. " .	12·0	18·0	24·0	30



1. WASTE OF HEAT DUE TO SCALE IN BOILERS

For small villa houses and cottages a water-butt should be placed to catch the rain-water. A rum-puncheon of 100 to 120 gal. capacity should be used where possible, and even a 40-gal. cask is not to be despised.

Soft Water by Distillation. Soft water is prepared by distillation from sea-water. Extremely efficient appliances for this purpose render such water available for industrial and domestic purposes in seaside places where other water cannot be obtained at a reasonable cost. Of course, such apparatus is indispensable on board ship on long voyages. By such a process water is not only freed from its mineral constituents, but it is also rendered sterile.

Scale in Boilers from Hard Waters. But the chief purpose for which water is softened is for steam raising. Here, softening is not a matter of convenience, but of necessity, to ensure both safety and economy.

As Harold Collet stated: "The waste of fuel occasioned by scale and blowing out must be remembered when considering the cost of a water supply, from whatever source. The cost of the water before it enters the boiler is a mere nothing compared to the cost of evaporating it. Many waters would be dear at 1d. per 1000 gal.; others are cheap at 1s." Hard water wastes fuel according to the thickness of scale in the boiler. With a moderate thickness of scale the extra resistance to heating may be twenty times as great as that of the boiler shell itself. The diagram [1] shows graphically the waste of heat entailed. There is also risk of explosion owing to the unequal heating of the boiler shell.

Water-softening by Chemicals. The hardness of water may be described as of two kinds —*temporary* and *permanent*— the former so called because it can be removed by prolonged boiling.

Temporary hardness is due to the presence in the water of bicarbonates; that is to say, lime and magnesia combined in certain proportions with carbonic acid. Bicarbonate of lime is so called because it consists of two equivalents of carbonic acid and one equivalent of lime; it is soluble in water, and is contained in most natural waters. On the other hand, carbonate of lime—that is, one equivalent of carbonic acid combined with one equivalent of lime—is insoluble in water, and therefore, if formed, separates out from solution. If, therefore, the bicarbonates can be converted into carbonates, they will come out of solution as a deposit, which can be removed, and the temporary hardness so got rid of. It is obvious from the foregoing that the bicarbonates can be converted into carbonates by removing one equivalent of carbonic acid, and this can be done in two ways—either by boiling the water for some time, causing part of the carbonic acid gas to be driven off, by which the bicarbonates are converted into carbonates, or, secondly, by adding slaked lime—that is, pure hydrate of lime or calcium hydroxide—in the right quantity. One part of carbonic acid in the bicarbonate is taken up by this fresh lime, so that the soluble bicarbonates disappear with formation of insoluble carbonates.

Permanent hardness, like temporary hardness, is caused by the presence of certain salts in solution in the water, of which the more important are calcium sulphate (sulphate of lime), calcium chloride, magnesium sulphate, and magnesium chloride. All four compounds affect the test for hardness already mentioned. Calcium sulphate gives rise to the hardest scale, but can be removed by adding soda ash (carbonate of soda) to the water. What is known to chemists as "double decomposition" takes place. Sulphuric acid leaves the lime and combines with the soda, whereby are formed sulphate of soda, which does not form scale, and carbonate of lime, which is removed by subsidence or filtration. The insolubility of carbonate of lime is the prime factor in the change.

Water Softened by Heating. There are many forms of apparatus used for water-softening, all of which may be said to have been evolved from the same simple process first used by Dr. Clark, of Aberdeen, which merely consisted in adding clear lime-water to hard water containing bicarbonate of lime or magnesia in solution. This, by combining with one half of the carbonic acid, throws down a double precipitate of chalk. Prior to Clark's process, water was softened without any plant at all. Clark's process is expressed by the equation

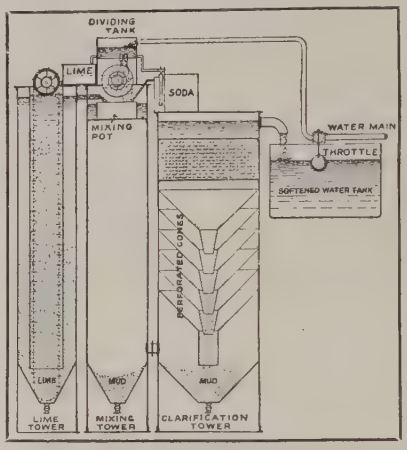
$$\underset{\text{Bicarbonate of lime (soluble)}}{CaH_2(CO_3)_2} + \underset{\text{Lime}}{Ca(OH)_2} = \underset{\text{Chalk (insoluble)}}{2CaCO_3} + 2H_2O$$

The softening of water by heating is expressed by the simple equation

$$\underset{\text{Bicarbonate of lime (soluble)}}{CaH_2(CO_3)_2} = \underset{\text{Chalk (insoluble)}}{CaCO_3} + \underset{\text{Carbon dioxide}}{CO_2} + H_2O$$

Upon this principle one of two well-known processes are based, notably on the Continent. Thus we have Scham's apparatus, in which water is forced into a dome, passing as a fine rain through perforated grids, mounted so that the holes do not come vertically over one another, the waste steam from the boiler passing between and heating the water sufficiently on its way downward to cause it to deposit its lime salts before it passes into the boiler. We have also Howatson's softener, a cylindrical reservoir containing plates arranged in stages in a manner so that the water travels in a zigzag fashion until it reaches the bottom, when it is softened, a ball-cock at the bottom regulating the inflow at the top. For further information regarding such processes, see "Industrial Use of Water," by H. de la Coux (Scott, Greenwood & Co.).

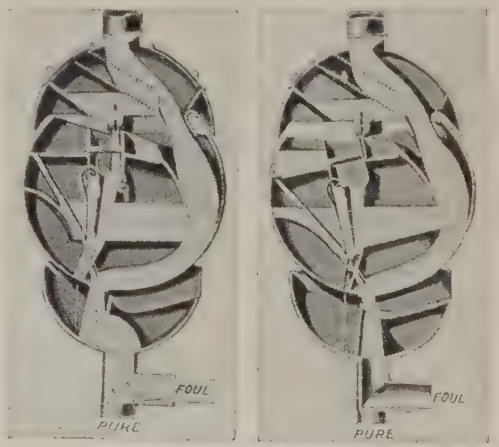
3. STANHOPE CLARIFYING TOWER (Stanhope Engineering Co., Ltd.)



2. DIAGRAM OF STANHOPE WATER SOFTENER
Stanhope Water Engineering Co., Ltd.

The Stanhope Softener. In the Stanhope Water Softening Process [2 and 3] we have illustrated an effective means of removing the sediment by gravitation. The water from the main, which is automatically controlled by means of the throttle, enters the top tank just in proportion as it is removed from the softened-water tank. In its flow through the driving tank and the mixing-pot it drives a water-wheel, which in turn drives a mechanical stirring apparatus for the lime-water. A continuous stream of clear saturated lime-water passes to the mixing-pot, together with the water to be softened and the soda in proportion required. It then passes down the mixing tower, where some sediment is deposited, and up the clarifying tower [3], where the rest of the deposit is caught by settlement on the cones, and drops to the bottom through the spouts. The softened and clarified water emerges from the top. The process is entirely automatic; and as long as the apparatus is charged, and periodically blown off, it can be kept going indefinitely.

The Collet-Stanhope Water Softener is somewhat different from the foregoing, as shown in 5.



4. ROBERTS RAIN-WATER SEPARATOR
A. shows impure water passing to waste;
B. shows pure water passing to storage.

The Criton Softener. In the Criton Water Softener [7, page 3431], made by the Pulsometer Engineering Company, accurately measured quantities of hard water, lime-water, and soda solution are discharged together into the mixer at every discharge of a large siphon tank. The capacities of the two reagent measures can be easily and rapidly varied when required. The discharge of the reagents is exactly dependent on the quantity of water to be softened. If this is reduced, the siphon tank fills fewer times per hour, and consequently the number of times the reagent measures discharge is reduced in proportion.

The discharges from the hard-water siphon tank and from the lime and soda tanks all meet at the same time and at the same place—namely, the mixer—and are violently dashed together, thus ensuring an immediate and thorough mixture. From the mixer the treated water passes through a down pipe to the bottom of the settling tanks, whence it steadily flows upwards, depositing in its progress the heaviest of the suspended matter, caused by the action of the softening process. From here it passes through the filter, emerging at "filter outlet" soft and bright. The filter is cleaned, without the removal of the filtering medium, merely by opening and closing certain valves. The lime tank is recharged with lime daily, and the spent lime drawn off.

Permutit. This substance, which marks a departure in the softening of water, is an artificial zeolite of approximately the following composition:

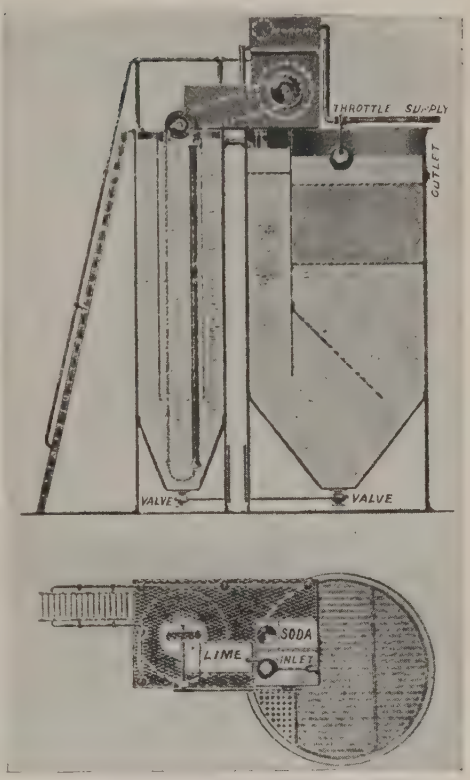
$$2SiO_2Al_2O_3Na_2O.6H_2O.$$

On passage of water to be softened through a mass of this sodium permutit, as it is called, it becomes converted into the calcium or magnesium salts, and the lime and magnesia salts in the water become converted into the corresponding soda salts, which, of course, are devoid of hardness.

As sodium permutit, the condition in which it is used, it is of a moist nature, granular and flaky, and possesses a lustre like that of mother-of-pearl. This constitutes the active agent in softening the water. When the whole of the mass is converted into calcium permutit, it has merely to be revivified by treatment with a solution of brine, which turns it back into the sodium salt for use over again. The final waste product is calcium chloride. Two illustrations show the appliances used by Water Softeners, Ltd., both for use by the gravity and pressure systems [6].

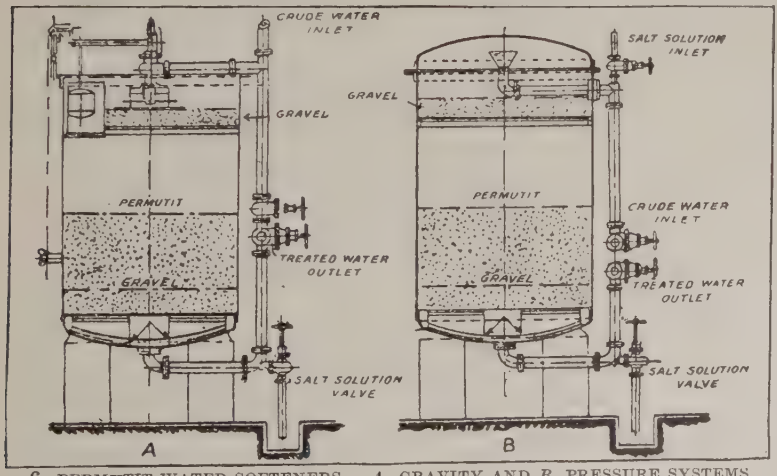
The softener consists of a cylindrical tank, either of the open (gravity) or closed (pressure) type, containing filters of gravel and permutit, with suitable arrangement of pipes and valves for washing and regenerating, together with a small tank for the salt solution.

The water enters through the crude water inlet-pipe, and, passing through permutit, is deprived of all the calcium and magnesium salts (which combine with the permutit). It is then delivered at the treated water outlet, clear, absolutely soft, and free from all hardening salts.



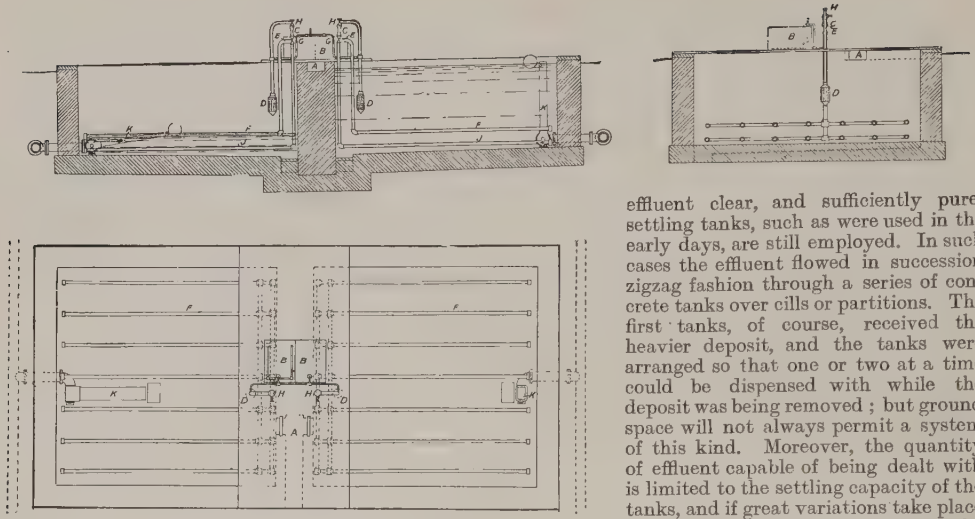
5. COLLET-STANHOPE WATER SOFTENER
(Stanhope Engineering Co. Ltd.)

The cleansing of the permutit is carried out by merely reversing the flow of the water through the filter. For regeneration a 10 per cent. salt solution, contained in a tank placed above the filter, is allowed to run slowly through the permutit after cleansing. This operation takes about eight hours, and requires no attention. The filter is afterwards washed with the hard water until free from salt, when it is again ready for use. These softeners can be built in single units of a capacity of from 10 to 10,000 gallons per hour, and in multiple units to any size



6. PERMUTIT WATER SOFTENERS. *A*. GRAVITY AND *B*. PRESSURE SYSTEMS

Settling Accelerated by Agitating. In Clark's process the precipitate is allowed merely to settle in large concrete or iron tanks, and the clear water is drawn off from the top. The precipitation is comparatively slow; but if the deposit at the bottom is stirred up each time, the settlement of fresh deposits is much accelerated, on account of the heavier crystals entangling and carrying down the lighter ones. This principle is carried out in a scientific way in plant constructed by



7. PATENT EFFLUENT WATER PURIFIER
(Mather & Platt, Ltd., Manchester)

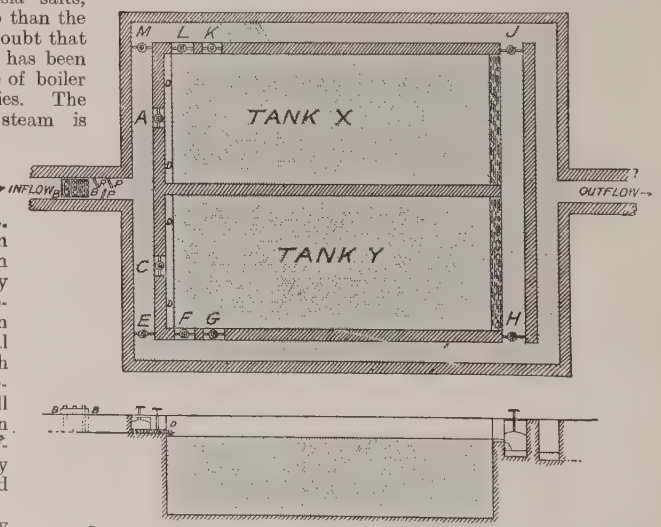
Messrs. Mather & Platt, of Manchester [7], which can be understood by reference to the figures: A, Effluent water inlet; B, tank for dissolving chemicals; C, blower for air and mixing chemicals; D, perforated rose; G, three-way tap; H, air tap on blower; F and J, perforated pipes for air; K, floating discharge pipe. The blower not only disturbs the sediment, but mixes the chemicals. A great saving in time of settling is established, and consequently a greater output of softened water is obtained. Furthermore, the plant is suitable not only for ordinary softening, but for purification. Some waters which are not amenable to carbonate of soda and lime treatment alone can be treated by the use of these chemicals in conjunction with alum. Water so softened is also rendered organically purer, as careful trials have proved.

The Removal of Grease from Water. The removal of lime and magnesia salts, although important, is not more so than the removal of grease, as there is no doubt that the presence of grease in feed water has been frequently the cause of the collapse of boiler tubes and other serious casualties. The removal of grease from exhaust steam is effected by oil separators, such as Baker's [9], of which there are many sizes and patterns to meet the various requirements.

Treatment of Effluents. The purification of effluents from different works has largely been forced upon the manufacturers by legislation, but of later years the products resulting from such purification have been found to be of industrial importance, and therefore in such cases, even if restrictions were removed, the manufacturers would still continue the processes of purification for their own advantage. An important case in point is the recovery of waste liquors from esparto and wood boiling [see Paper-making].

Where mere subsidence will carry down the particles and leave the effluent clear, and sufficiently pure, settling tanks, such as were used in the early days, are still employed. In such cases the effluent flowed in succession zigzag fashion through a series of concrete tanks over cills or partitions. The first tanks, of course, received the heavier deposit, and the tanks were arranged so that one or two at a time could be dispensed with while the deposit was being removed; but ground space will not always permit a system of this kind. Moreover, the quantity of effluent capable of being dealt with is limited to the settling capacity of the tanks, and if great variations take place in quality and quantity of effluent, the treatment is likely to be unsatisfactory. It must be admitted that the Rivers Commissioners are very reasonable in their requirements, and so long as manufacturers show that they are exercising their best endeavours to fulfil such requirements they are not unduly harassed; but upon the manufacturer is placed the onus of devising a scheme for the treatment of his effluent, and it necessitates a great deal of ingenuity on his part to choose between the many well-known processes so frequently brought to his notice.

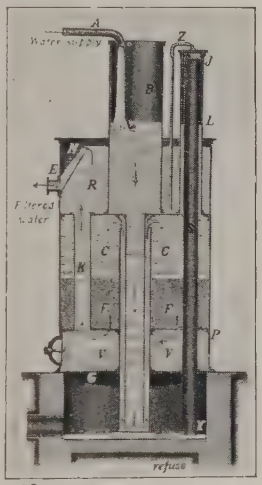
We have known cases where troublesome effluents have been treated at very small outlay by digging sumps where the ground is impermeable, and causing the water to flow over a succession of terraces like those arranged for watercress beds. Such primitive appliances at times do more to satisfy requirements than complex filters. Figure 8 shows an arrangement of settling tanks.



8. TANKS FOR PURIFICATION WITH ALUMINOFERRIC
(Peter Spence & Sons)

"Reisert" Automatic Self-cleaning Filter. This [10] is used for clarifying turbid or muddy water for industrial purposes. The water to be filtered is received into the chamber B, and flows downwards, following the course of the arrows into the chamber C, and so reaches the filter bed, F, through which it percolates, leaving the mud, etc., on the upper side of the bed. The filtered water is received into chamber V, and finds its way upwards *viâ* pipe K into chamber R, and finally overflows the diaphragm, N, into the filtered-water outlet, E. Obviously, the rate of filtration will vary with the state of the filter bed and the head of water in B. As the filter bed fouls and the resistance to the flow of the water increases, the water level in B rises and establishes a corresponding level in the pipe L, which, it will be observed, is in connection with C. Inside this annular pipe, L, is another pipe, S, which extends from nearly the top of L right through the filter bed and receiver V to the waste water channel G, forming the base of the filter. As the water rises in L, in sympathy with B, there presently arrives a time when it overflows at J, and so forms a syphon. The current through the filter is thus rapidly reversed, the water in R flowing back through K and upwards through the filter bed, the deposit on the filter being thoroughly disturbed and carried into the waste channel, G. The chamber R is proportioned to contain sufficient water to effect this cleansing operation thoroughly, and as this chamber empties, air enters and destroys the action of the syphon, and the cleansing ceases. The filter then resumes its normal working. The cleansing operation is repeated as often as the state of the filter requires, and is entirely automatic.

9. THE BAKER OIL SEPARATOR



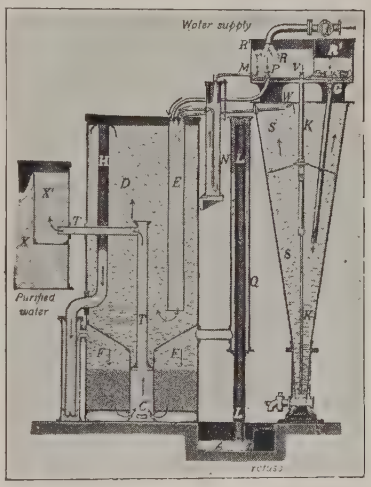
10. REISERT AUTOMATIC SELF-CLEANING FILTER (Royles, Ltd.)

The same system is used in conjunction with the water softener [11]. This latter is peculiar in its construction, and different from any of the foregoing. The lime saturator, S, is cone-shaped. The charge of slaked lime is inserted through tank R′ once daily.

By a constant uniform water supply from the distributing tank, R, which is conducted downwards through the central pipe, K, through micrometer valve V, the lime paste at the bottom is stirred up and thoroughly impregnated, so that it rises at first partly with the water, until the rapidity of the rising water diminishes so much, owing to the upward widening shape of the saturator, that the undissolved lime particles are no longer able to follow, so that the saturated lime-water clarified, then leaves the saturator, S, at the top, through the pipe W, and is carried away into the reaction chamber, D, by way of the mixing pipe, E. The soda apparatus is charged with strong soda solution once daily, and being much heavier than water, it remains at the bottom.

The water flowing from the distributing tank, R, through the small micrometer valve M—which is adjusted in accordance with the amount of soda required—into the soda chamber, N, remains always on the surface of the soda solution (no mixing occurs) and displaces the same, it being carried through the small pipe from the bottom upwards, and into the mixing pipe, E, and finally into the reaction chamber, D. The softening takes place in D, and the water, after softening, passes down through the filter, F, up into the tank X′, where it overflows into the tank. N is the syphon for flushing the filter. In all respects it acts in a similar way to the cleansing filter already described [10].

The "Torrent" Filter. This represents a type with which we have not dealt. It is extremely simple, and costs very little for upkeep.



11. REISERT AUTOMATIC SOFTENER (Royles, Ltd.)

The great feature of this filter is that the filtering medium is cleansed and revivified by introducing for a few minutes, at intervals of about ten hours, a jet of air under high pressure produced by the aid of a steam blower, and at the same time admitting a reverse current of water. The violent agitation so produced causes the whole of the filtering medium and contained impurities to boil up, as seen in **12.** The particles of dirt are washed away and discharged through the outlet, leaving the filtering medium clean. The medium never requires to be replaced by fresh, and what little there is lost through the dirt is easily made up by the addition from time to time of small quantities. The filtering medium is chosen to suit the requirements of the particular water which is to be treated. There are no mechanical moving parts to get out of order.

Filtration. For laboratory work special filters are constructed, the simplest, perhaps, being the Kitasatos porous tubes in addition to which we have the Chamberland porous filter [14], which can be mounted in metal tube with stopcock to fit

a water supply. There are also the Massen filter candles with porcelain heads [15], and the well-known Klein laboratory filter, fitted with Pasteur-Chamberland filter tube [13].

For domestic work we have very much the same kind of contrivance working under pressure. In some of them dirt is quickly removed by the reversal of the current of water. Numerous other filters and water softeners, both for domestic and manufacturing purposes, have been invented, and are in use, but it has been possible to consider only some of the typical processes here. One of the most simple and effective for the clarification of an ordinary mill effluent is that recommended by Peter Spence, to be employed in conjunction with aluminoferric, which is now so much used for the purpose.

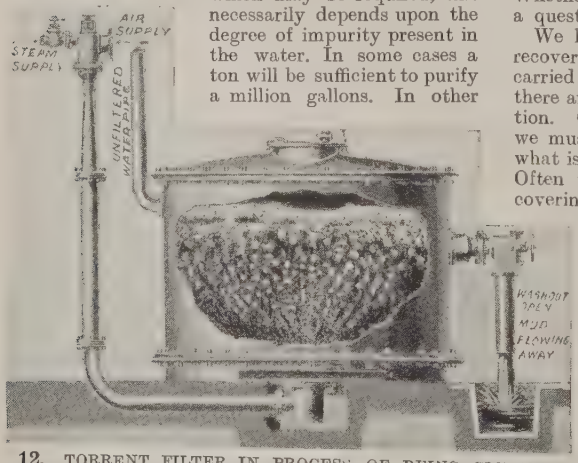
How to Apply Aluminoferric. Figure 8 gives a general idea of the method of using aluminoferric, also of a system of settling tanks which, we think, may with advantage be adopted by many manufacturers for purifying their waste water. BB represents the box or cage containing the aluminoferric standing in the channel or conduit. PP represents a series of baffle plates to insure the aluminoferric being thoroughly mixed before flowing into the tanks. The two tanks shown may be used in two different ways as may best suit the special circumstances of each manufacturer.

13. KLEIN'S LABORATORY FILTER

They may be used independently by opening A and C and closing E and M. The treated water will thus pass into both tanks, where precipitation will take place, and, when full, will flow over the sill at the end, and, H and J being open, the clarified water will pass away into the outfall.

Alternately, C and E and M being closed, the treated water will flow into tank X, and passing forward will overflow into the channel at the end, and H and J being also closed, the water will flow into tank Y, and F and G being open, will flow into the side channel and pass away into the outflow as in the first instance. Or the working as described may be reversed by closing A and M and opening K and L.

With regard to the quantity of aluminoferric which may be required, this necessarily depends upon the degree of impurity present in the water. In some cases a ton will be sufficient to purify a million gallons. In other instances, where the water is highly impure, experience shows that it may be necessary to use a quantity equal to two tons per million gallons.



12. TORRENT FILTER IN PROCESS OF BEING CLEANED
(Pulsometer Engineering Co., Ltd.)

The price of the aluminoferric may be taken at £2 15s. per ton, in four-ton lots, delivered at railway station within, say, 50 miles of Manchester or Goole. The superior results obtained by this process have enabled manufacturers in many instances to utilise the clarified water for manufacturing purposes, and where this has been done, it has been found that the purification is accomplished practically without expense.

Recovery of Fibres. Objections are raised to effluents from mills containing fibrous particles, which may be harmless in themselves but will spoil the appearance of the stream. They are frequently collected for economic reasons and used again in the manufacture.

Perhaps the simplest appliance for catching fibres from effluent is an ordinary "save-all," which consists of a revolving cylinder slightly tapering and revolving slowly on a horizontal axis and covered with fine wire gauze. The water passes in at the small end and drains through, the fibre is caught and discharged at the other end of the drum. The well-known Fullner Separator, which takes the fibres out by a process of settlement, has now become a part of the general equipment of a mill. After this clarification process, the fibre collected is used again in the manufacture.

We do not profess to deal with the subject of sewage purification [see page 3686], but there is no hard and fast line dividing such purification from that of mill effluents, because the latter includes many cases which require to be submitted to similar treatment to sewage, as, in addition to removing chemical impurities, it becomes frequently necessary to destroy organic contamination. We have, therefore, practically all the methods of sewage purification employed in conjunction with existing works on effluents, even to the bacterial process.

Can Waste Products be Utilised? There are many so-called waste products which are now turned to useful account, and therefore no longer regarded as such. In fact, as we all know, there should be no such thing as a waste product. Whether or not it can be utilised becomes merely a question of cost.

We have to inquire under what conditions the recovery process and utilisation of waste can be carried out economically. To answer this question there are several factors to be taken into consideration. Quite apart from the nature of the products we must know the quantity to be treated, and, what is even more important, the state of dilution. Often the quantity is insufficient to pay for recovering, even although excellent processes may be elsewhere in operation. If waste liquors are to be treated they must not be too dilute; thus it pays to recover the alkali from esparto liquors but not from rag liquors, as the latter are usually too dilute and the cost of evaporation would be too great. It might, however, pay where esparto and rag liquors are treated together.

As another illustration, we recently examined a quantity of waste fibrous material with a view to utilising it or finding a suitable outlet. We found that the material yielded, on dry distillation,

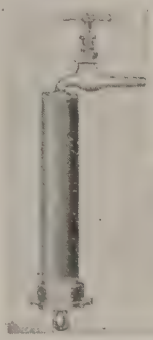
a high percentage of acetic acid and wood spirit; but although some hundred tons were available per annum, the quantity was too small for a plant to be constructed to work it economically. In such a case the only alternative is to look around for similar waste products which could be treated in the same plant.

Slag and Mineral Refuse. Considerations such as we have outlined above apply to practically all waste products. Take, for instance, the case of blast furnace slag. Enormous quantities of this material have been accumulating, and may be seen as huge mounds or heaps by the side of the furnaces. Numerous projects have been put in hand for utilising this waste, but consider some of the initial difficulties. In many parts furnaces are scattered up and down the country in twos or threes, and to utilise the slag economically it must be worked up on the spot. We will suppose plant and machinery is installed, what is to happen when that particular heap of slag is exhausted, and it costs too much to bring it from a distance? Nevertheless, slag is being employed for a number of purposes. In many parts it is used as a road metal, although not very suitable for this purpose. It is also used for making bricks, paving slabs, wall copings, ornamental blocks, etc., with the addition of lime and cement as bonding agents. Other waste materials, such as slate refuse, clinkers from destructors, stone chippings, and even sand may be similarly treated. These materials are first fed into a heavy revolving grinding mill, and reduced to fine powder by passing through screens and returning the coarse stuff to be reground, as described in the manufacture of ordinary bricks [see page 1799]. The resulting ground material is then measured out with the "bond," whether lime or cement, in the correct proportions, and delivered into a mixer under a spray of water, and thence the material passes to the mixing pan—a machine similar to, but lighter than, the grinding mill, and, when reduced to the correct consistency, it is conveyed to the brick-making machine. The moulded bricks are dried either in the usual manner by air hardening or by a more rapid process. By heating the bricks in an autoclave [16] under 120 lb. steam pressure, they can be hardened and ready for the market in 24 hours.

Blast furnace slag and Portland cement resemble one another in composition, and successful attempts have been made to prepare cement from this material, but in spite of all inventions there is plenty of slag left for the chemist to work upon.

Other Examples. Numerous examples of the utilisation of waste products will be found in studying any industrial process. Thus, the glue-maker depends on the waste pieces of hide or leather clippings and the waste bones from the slaughter-house or dust heap [see page 5067]. The manufacturer of animal black uses waste animal refuse of all sorts. The farmer feeds his stock on cotton-seed or linseed cake, from which the valuable oil has been extracted [see Cattle Foods], on bran and pollard from the flour-mill [see page 5272], on brewers' grains [see Brewing], and numerous other so-called "waste products," of which not an ounce is really wasted.

Sometimes the waste is employed again in the same factory in which it was originally produced, as in the case of metals melted down for use again, or in the "regeneration" of waste rubber. Perhaps coal-tar is the most striking instance of what was once but can no longer be regarded as waste [see page 5197].



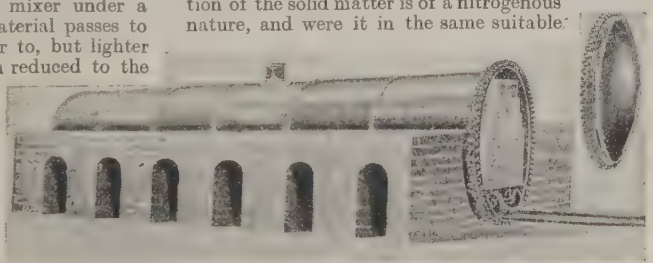
14. CHAMBERLAND POROUS FILTER

15. MASSEN'S FILTER CANDLE

One of the most troublesome sources of contamination to streams is the effluent from flannel mills which is derived from the processes used in washing wool. Wool always contains a proportion of fatty substances, the greater part of which, however, resemble fat only in appearance, and not in chemical properties. These consist of a body termed *cholesterine*, belonging to the class of substances known to chemists as *alcohols*. Chemically, wool fat is more difficult to decompose than ordinary fats, and, in consequence, hangs about and contaminates any water or stream into which it finds its way. As potash is used in wool-washing, it pays to evaporate the waste liquors instead of allowing them to become an effluent, and, after concentration, to ignite them, when the potassium is recovered in the form of potassium carbonate. The ash is lixiviated, and the liquor used over again for wool-washing.

One of the waste products for which no really satisfactory use has been found consists of the sulphite liquors remaining over after the preparation of wood pulp [see Paper-making]. These liquors have been worked up for the separation of sizing materials, but without much commercial success. The latest attempts lie in the direction of the production of cattle foods, but reliable data are not yet to hand.

Perhaps one of the most difficult of all problems is the utilisation of town refuse. A large proportion of the solid matter is of a nitrogenous nature, and were it in the same suitable condition as it is sometimes found in country districts, it would prove a most valuable manure. Unfortunately, in large towns and cities it becomes diluted with such large volumes of water that the economical separation of the more valuable constituents becomes one of the most difficult problems with which we are faced. On the other hand, we cannot but view with concern the large quantities of combined nitrogen which are constantly being removed from the soil and deposited in the sea. The solid matter of town refuse is now frequently burnt, combustion taking place in special furnaces or destructors. In many towns the heat so produced is utilised for steam-raising.



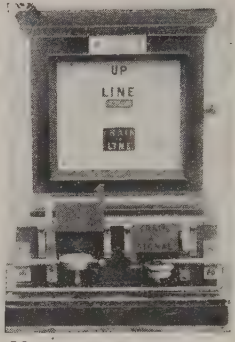
16. JOHNSON'S AUTOCLAVE, OR HARDENING CHAMBER
(William Johnson & Sons, Leeds)

CLAYTON BEADLE AND H. P. STEVENS

MODERN DEVELOPMENTS IN SIGNALLING

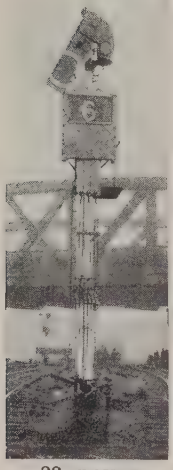
18. CENTRE-PIVOTED SEMAPHORE, G.N.R.

19. UPPER QUADRANT SEMAPHORES



20. BLOCK TELEGRAPH INSTRUMENT

21. DWARF ALL-ELECTRIC SIGNAL



22. ROUTE INDICATOR

23. ALL-ELECTRIC POWER-SIGNAL FRAME, WITH ILLUMINATED TRACK DIAGRAM ABOVE IT

24. ELECTRO-GAS AUTOMATIC, N.E.R

25. AUTOMATIC SIGNALS, LOW-PRESSURE PNEUMATIC SYSTEM, L. AND S.W.R.

Signalling Systems and their Methods of Working. Railway Brakes. Vacuum and Westinghouse Systems.

RAILWAY SIGNALS AND BRAKES

BRITISH railways are worked on the absolute block system, the object of which is to maintain a certain interval of space between all trains, instead of an uncertain interval of time as formerly. The line is divided into sections, varying in length from a few chains to several miles, according to the volume of traffic. A signal-box is placed at the termination of each section, and provided with a number of fixed signals outside, and within are the levers that actuate the movements of the signals and points, together with electric bells, block telegraph instruments, and telephones. The principle of the block system is that two trains travelling on the same set of rails shall never be in the same section at the same time, though this rule is relaxed in certain circumstances by employing what is known as the *permissive block* system, which is governed by stringent conditions.

Semaphores. The form of fixed outdoor signal generally adopted is the *semaphore*, which consists of a timber or iron pole, varying in dimensions according to circumstances, but usually from 20 ft. to 30 ft. high, with an arm about 5 ft. long, capable of assuming two positions when actuated by mechanical force. When this arm is in its normal position—namely, horizontal and at right angles to the post—it signifies "stop"; when it is turned at an angle of 45 deg. downwards it indicates "go on." Of all semaphore signals none has a less equivocal "go on" or safety position than the Great Northern pattern. The arm, being centre-pivoted, does not fall, but jumps out from the post, and turns a somersault, so to speak, in assuming a position quite parallel with the latter [18].

Foreign railways employing semaphores have almost invariably preferred the upper quadrant type [19], in which the arm is moved to an angle *above* the horizontal position for the safety indication. This movement has the advantage of needing no counterweights to make the blade automatically assume the danger position, should any of the fittings fail; while it enables the signal to be placed at a low height above the ground, thus rendering it easier to sight under bridges. The first upper-quadrant type of signal seen in this country was when the Metropolitan Extension Railway was entirely re-signalled on this principle in 1910.

The face of every semaphore signal is painted red, with a white band, spot, or stripe; while the back is painted white, with a black band, spot, or stripe.

Selection of Position of Signals. All semaphore signals are placed in such a way that on approaching them the arm appears on the left-hand side of the post, and, except where the line curves sharply, the signal-posts are kept as far as possible on the left-hand side of the track, in the direction in which the trains travel. When two or more posts are clustered together, controlling several lines of way, the signal on the extreme left refers to the track on the extreme left, and the second to the second from the left, etc. In the signalling of two or three lines of way branching out from a common line at a junction it is, however, usual to bracket the posts, in which case the posts often number in height from the right, the tallest referring to the fast or main line, the next highest to the second line from the right, etc. In the event of the main line being on the extreme left, this procedure, of course, is reversed. At junctions the posts, whether placed separately or bracketed, agree with the geography of the route. Some companies further distinguish the signal arms that refer to the slow or loop lines by giving them hoops. Three or four arms referring to different lines should never be placed one below the other on the same post; each line should have a separate post or bracket.

When the railway is much enclosed by buildings, it is often necessary to employ very high signal-posts, in order to obtain a sky background for the blades. Signals elevated more than 45 feet above rail-level are furnished with a replica arm on the same post, 15 feet above rail-level. The high arm is seen against the sky for some distance away. As the train comes nearer to the post, the high arm grows less easy to see, and the low arm more so.

Signals Under the Block System. Under the *block system* the outdoor fixed signals are divided into home signals (outer and inner), distant signals, starting signals, advanced starting signals, calling-on signals, and backing signals.

All except the "distant" are stop or danger signals, and every stop signal defines a limit for traffic movements. The home signal marks the termination of one block section, and the starting signal the beginning of another, while the space between them—sufficient to take the longest train—is a kind of neutral zone. When, however, the points worked from a signal-box are numerous, and are spread over a considerable length of main line, it may be desirable to subdivide this zone by means of an extra or inner home signal, in which case the home signal first come to is called an *outer home*. The distant signal, which is differentiated from the others by cutting a notch in the end of the blade, instead of leaving it square, is placed in front of the home, the distance depending upon the gradient of the line, but 1000 yards is about the limit. Its function is merely to warn the train that it is approaching a home signal, and it is so interlocked that it cannot be turned to safety when the latter signal is at "danger."

The *starting signal* notifies the driver when he may enter the section in advance, provided that there is no advanced starting signal, but where this latter exists the starting signal only gives permission to go to the *advanced signal*, which is provided for the purpose of allowing a train which has to pass the starting signal, in order to pick up waggons from sidings or to clear the neutral zone, to be brought to a stand without entering the section in advance.

Calling-on and *backing signals* control short shunting movements, either within or just beyond the neutral zone. They are distinguished from other signals by having shorter or skeleton arms.

All semaphore signals project from the left-hand side of the post, and wherever possible the posts should be placed upon the left-hand side of the

line to which they refer. It is not considered safe to place any stop signal in such a position that a train standing at it is out of the signalman's sight, unless some means of indicating the presence of the train is provided in the signal-box. This is mechanically accomplished by means of *train safety bars*—depression bars, which stand normally at rail level, and are depressed by the passage of wheels over them. The depression of the bar is caused to actuate a lock by which the movement of a signal or point lever is prevented as with a lifting bar. Sometimes the depression bar is used to break an electric circuit with the same result.

Again, it is essential that the signalman should know the exact state of signals hidden from his sight by curves, bridges, or other impediments to his vision. Therefore, all signals so situated are furnished with electric repeaters to the signal cabin, which not only imitate the movements of the arm —viz., "on," "off," and "wrong"—but also show "light in" and "light out," one wire only being required for the five indications. In important junction and terminal station boxes several other kinds of electric tell-tale instruments are in use, as, for example, train-starting indicators, which announce when trains are ready to start from the different platforms; and route indicators, which advise which route a train is to take.

Controlled and Slotted Signals. We have said that ordinary signal-arms ought never to be placed one below the other on the same post. Nevertheless, in cases where the block sections are short, it is advisiable to have the "distant" of the section in advance placed upon the home, starting, or advanced starting post of the section in rear, when the "distant" must be the lower arm. Both signals must then be mechanically "slotted" in such a way that the "distant" can never be taken "off" when the "home" above it is "on"; while, in order to avoid the discrepancy of the "distant" showing "off" when the home is "on," the home signalman must be able simultaneously to place both to "danger" as soon as a train passes.

Route-indicator Signal. When one line leads into several roads, as, for instance, at the approach to terminal stations, simplicity combined with economy in signal posts, arms, and lamps is effected by employing a *route-indicator signal* [22], consisting of a single arm, and below it either a numeral route indicator or a destination board, which is illuminated at night.

Some Minor Signals. Either small disc ground signals or dwarf semaphores [21] are generally employed to indicate the position of the points at a cross-over or at the entrance to sidings. The former signal is a disc of metal, with a lamp carried on a spindle, which turns on its axis. The position of the disc by day and the colour shown by the lamp at night furnish the necessary indications as to which way the points are set.

Indications at Night. In the case of semaphore signals these are given by two differently coloured glasses, through one of which at a time the light of a lamp shines. The coloured glasses are contained in a "spectacle frame," which moves in unison with the signal-blade. A red light indicates "danger" and a green light "safety." No other light is allowed in the case of stop signals for the following reason: If a coloured glass falls out of the spectacle frame the light is shown white, and a driver knows that something is wrong; whereas, were red and white lights used, the falling out or breakage of the red glass might not be detected, because a driver would take the white light for a genuine safety signal.

A problem which has not yet been satisfactorily solved is how to distinguish in the dark a distant signal in the "on" position from a stop signal, as both show a red light. Some years ago the London and North-Western Railway adopted a purple light for the distant signal, but after a longish trial abandoned it. In the United States they use an orange light for the distant signal, and this was recently adopted by the Metropolitan District Railway. When the orange light is employed, it is customary to colour the blade of the semaphore orange, with a black band or stripe, instead of red, with a white band or stripe.

Some companies employ a patent lamp having a copper extension, in which is inserted a ground-glass "fish-tail." The lamp, therefore, exhibits the "fish-tail" mark on the right of the usual light, and the distinction can be sighted 250 yards away. The latest device is, however, a red flash-light.

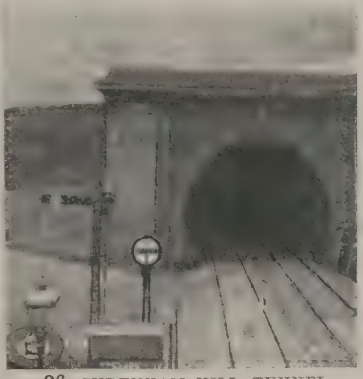
It was formerly the custom to use red and green lights with every variety of ground point-signals, but a number of railway companies for some time past have substituted a small white light for the previously existing red light in such signals as ground discs, siding, and backing signals. The object of the change is to prevent confusion between main and subsidiary signals, and to improve the appearance of station yards at night from a driver's point of view, and it is claimed for it that in the event of a red lamp being exhibited on occasion of emergency the possibility of its being observed and acted upon is much more likely than on those lines where red lights are provided for the ground signals.

Restricted Speed Indicators. Speed restrictions, imposed round sharp curves, through junctions, or for other reasons, are sometimes not too seriously regarded by drivers, owing to the general absence of a warning board, while when the latter is provided it is rarely illuminated at night. To remedy this omission the London and South-Western Railway began to install day and night *restricted speed indicators* in 1911. The first indicator, which is fixed about a quarter of a mile ahead of the point where the restriction of speed begins to take effect, carries numerals representing the number of miles per hour to which the speed is restricted. The next post, carrying the letter "C," indicates the point where the speed restriction begins, and a third post, carrying the letter "T," marks the point where the restricted speed ends and normal speed may be resumed. The face of the lanterns is made of translucent glass, with the numerals and letters painted upon it. Behind the glass are two long-burning oil-lamps, kept continuously burning. By day the white glass forms a good ground for the black figures painted on it, and by night the light of the lamp forms an equally bright ground.

Interlocking Signals and Points. But the fixed signals do not do more than direct train movements. To turn a train off one line of way and on to another connecting with it, a pair of tapered movable rails, called *switches* or *points* [29], are utilised. If these points lie towards a train they are termed *facing points;* if in the reverse direction, *trailing points.* [See page 2963]. Facing points are to be avoided as much as possible. Thus, a train generally enters a siding, or crosses from one line of way to another, by means of trailing points—that is to say, it backs. Both signals and points are actuated from a signal cabin, and, in order to

prevent contradictory movements on the part of each, the signal and point levers are concentrated in one frame, and mechanically interlocked. Consequently, the locking frame [30] of an important signal-cabin is a wonderfully complex piece of mechanism.

Among the refinements that tend towards the perfection of interlocking, mention must be made of the following. The *locking bar* is a long, flat bar lying along the edge of a rail and close to a switch. Each time the switch is moved this bar must be raised above rail-level. Thus, a train travelling through the points is master of the situation; not even the signalman can either intentionally or inadvertently change their position. The *detector lock*, if, owing to a broken rod, the points have not been moved, prevents the signalman from lowering any signal which would be contrary to the actual position of the points themselves. The *facing-point lock* ensures that the points are properly set close home to the stock or fixed rail; otherwise the road cannot be signalled clear. The *clearance bar* consists of a series of locking bars, placed between the starting signal and the signal-box, and so long as a train is standing upon one of them the block instrument and home signal are automatically locked at danger, and a signalman is unable to commit an error should he have forgotten the presence of the train in question.



26. SYDENHAM HILL TUNNEL ELECTRO-MECHANICAL SIGNAL

Manual Operation of Signals and Points. Signals are worked by wires, and the points by rods connecting with their respective levers. Levers are of sufficient length to enable the signalman to manipulate them with moderate exertion, but, where signals are placed at long distances from the levers controlling them, counterbalance weights are provided both on the lever and on the signal-post to assist the operator. It should be added that the Board of Trade limits the distance at which trailing points may be manually worked from a cabin to 300 yards, and that of facing points to 250 yards.

27. TRAIN TRIP ON THE METROPOLITAN DISTRICT RAILWAY

The Signal-box. Great care is taken in the design of signal-boxes so that they shall be light and airy, and give those in charge a clear view of the track from every point. A gallery often runs along the front of the box, so that the signalman can go out to transmit messages to engine-drivers, guards, shunters, and others, without losing audible touch of his electric bell instruments. Every lever in the frame is numbered, and on the floor beside it or on a board in front of the frame there is fixed a brass plate engraved with its name and use—namely, "Up home," "Down advanced starting," "Main line cross-over," and so on. Sets of levers are distinguished by being painted in different colours below the handle and spring catch. The following is the standard colour arrangement: red for home signals, green for distant signals, black for points, white for spare levers, and fancy hoops for anything out of the ordinary. In junction boxes it will be further observed that many levers bear an array of numbers, sometimes a dozen or more. These numbers form the key to the interlocking. Before any numbered lever can be moved, each of the levers to which the numbers on it refer has to be pulled over in the order in which the numbers run. Above the lever-frame hangs a shelf, on which stand the block telegraph and bell instruments, repeaters, route indicators, telephones, and similar instruments, and above the shelf is displayed a large chart of the tracks, sidings, switches, cross-overs, and fixed signals controlled and operated from the cabin.

28. ELECTRIC CAB SIGNAL (N.E.R.)

Block Working with Three-position Instruments. The standard practice of absolute block working with three-position instruments (two-position instruments are practically obsolete) is as follows: A signal-box is placed at the termination of each section, and is provided with four block telegraph instruments [20], one in each direction for the up and the down line respectively.

On the approach of a train to A, the signalman there will call B's attention by a code of bell-beats, and then give the "Is line clear?" signal of inquiry. The signalman at B, having ascertained that the line is clear between A and B, replies by bell signal in the affirmative, and turns the handle of his block instrument so that the indicator or needle on his dial, as well as that on A's dial, points to "Line clear." The train may then be despatched from A. As soon as the train has left A, the signalman there must give B the bell signal "Train entering section," and B must acknowledge this signal, and unpeg his needle. The signalman at A must then give B the "Train on line" signal, by pegging over his needle to this indication, which causes B's dial to read the same. It is now time for B to call C's attention, and to give him "Is line clear?" signal. When the train has passed B's box, B rings his bell to A and moves his needle to zero, which indication is repeated on A's dial. The line is now closed between A and B, although no train is in it. As soon as the train has passed B it must be signalled as above directed to C, and so on throughout the block sections.

Lock and Block System. If a second train should arrive at a signal-box before the preceding one has been signalled as "out of section," it must be stopped and detained until the message has been received. Theoretically, therefore, there can never be two trains in the same section at the same time. But how are errors like the following to be prevented: B accepting a train from A when the line A B is not clear; A taking off his outdoor signals without asking B if the line is clear, or if to do so is contrary to the directions of his dial? The answer is by combining the block and interlocking systems by means of mechanical or electrical apparatus, so that any one signalman is rendered powerless to perpetrate errors, his actions being controlled either by the signalman on each side of him or by the train itself. This is known as the *lock and block system*, and it is usually dependent for its action in controlling the "line clear" indication on either a rail treadle or a rail contact, operated by passing trains. Nevertheless, this particular system has its weak points. "The depression of the treadle," writes Mr. C. B. Byles in his "First Principles of Railway Signalling," "is not an infallible signal that the section is clear, but merely that a vehicle of some sort, which may have come from a siding, has passed over it. Then there is the problem where to place this treadle. If placed too far ahead it is not actuated by trains which may have been shunted clear of the main line, and if placed too far back it is actuated and clears the section too early, as, of course, it is operated by the first wheel which passes over it." It is a confession of unreliability that it should be found necessary in all lock and block treadle systems to provide means whereby the signalman can himself effect release of block instruments independently of the train. Otherwise a man is liable to get himself locked up owing to signalling a train forward on the block instruments, which is shunted or cancelled, or perhaps some part of the electrical apparatus may not work exactly owing to tight adjustment. Therefore, it is necessary to provide a releasing key for the man to unlock himself, and herein lies the danger of a man making improper use of the key. This point has, however, been considerably met by it being necessary in modern lock and block instruments for the signalman on each side to co-operate in the releasing of the key.

Automatic Signalling. Automatic signalling, whereby the train provides for its own safety, has been perfected but recently, though it began to exercise a fascination for inventors at an early period. After many attempts, it was found that the ideal solution of the problem lay in track, or, more correctly, rail circuits. The London and South-Western Railway in 1902 was the first to install a long series of track-circuit automatic space signals [25]. The principle is as follows:

A low-tension current flows from a battery along one rail of the track through a relay, and back to the battery along the second rail. The relay makes and breaks a local circuit, which by means of electromagnets controls the mechanism, electric or pneumatic, or whatever it may be, for operating the signals. When the current is flowing along the line the relay completes the local circuit, and the signal is held "off." When, however, a locomotive or other vehicle with metal wheels and axles is in the section a short circuit is established in the track circuit, the relay becomes inoperative, the local circuit is broken, and the signal returns to "danger." By insulating the rail-joints at intervals the line is divided into sections, to each of which a separate current is supplied. Track-controlled automatic signalling installations, as a rule, revert to the normal "clear" position of signals; but the Hall system, installed on the North-Eastern Railway [24], conforms to the standard block regulations, keeping the signals at danger while the line is closed. With the Hall system, given a clear line, the train is made to take off the signals on approaching each successive block section. The track-circuit system is common to all modern installations of automatic signalling, though the signal movements themselves may be actuated either pneumatically or electrically, or by other means. The Hall system employs compressed liquid carbonic acid gas for energy, and the self-contained gas-motor possesses the advantage of obviating the use of separate batteries, air-compressing plant, pipe-lines, etc. Track-controlled signals convey a guarantee that the track itself is in good order, for, should a rail break, the danger signal would be given. If a permament-way man finds anything wrong with the track he can block the line at once by short-circuiting the rail-battery, with a crow-bar, or any metal tool of sufficient weight.

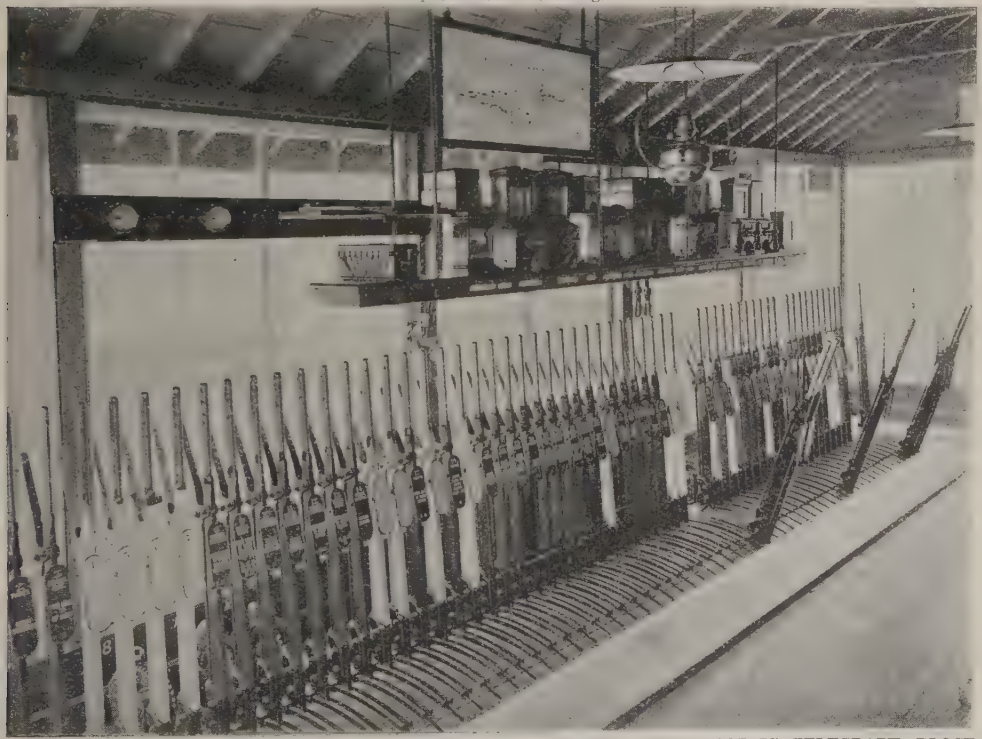
Illuminated Diagrams. By means of track-circuits the diagrams ordinarily used in signal-cabins, showing all the lines, sidings, junctions, and signals, can be made much more realistic. They can be converted into illuminated diagrams [23], which tell the signalman what lines are occupied, when connections are fouled, and when trains are approaching. These diagrams are painted on glass, which is opaque all over, except the roads. Electric lamps are placed behind the roads in the diagram, and are partitioned off in lengths to correspond with the track-circuit block sections; they are so controlled by the track-circuit relays as to be always alight, except when the circuit is opened, owing to the presence of a train in section, when the lights go out, and so advise the signalman that the section is occupied. Such an arrangement has proved indispensable on the Metropolitan District Railway and tube railways, where the signalmen are unable to see the points or roads they control, and it is now being adopted in large stations and shunting-yards where fogs are prevalent and much night work has to be carried on.

Advantages of Track-controlled Signals. Other advantages of track-controlled signals are as follows: Augmented track-capacity, for they enable a greater number of trains to be passed over a given stretch; uniform running of trains; a guarantee that the section is really clear. The wonderful frequency and regularity of the electric train services on the underground railways of London is only rendered possible by signals of this type, and the system as at present arranged allows trains to follow one another at an interval of eighty seconds, and even less. Although this method of signalling cannot be employed at junctions, the frames of these signal-boxes can be so arranged that for straight-through traffic the levers controlling the main-line signals can be pulled over and the box closed, resulting in automatic main-line signalling through a junction.

Train-stops. Where rail-circuit automatic signalling is in force there is but one loop-hole for error on the part of the human equation—the driver may nullify all its safeguards by disregarding the signal to stop. Inventors are now trying to solve this remaining problem by means of the trip or train-stop. Up to the present all such apparatus have taken a mechanical form, a ground arm or trigger, which acts in unison with the signal. When

29. POINTS AND CROSSINGS AT YORK STATION

A. Single junction; *B*. diamond crossing; *C*. single slip; *D*. double slip; *E*. cross-over road; *F*. scissors crossing; *G*. special scissors crossing.



30. SIGNAL-BOX WITH A SIXTY-FIVE LEVER-LOCKING FRAME AND ELECTRIC TELEGRAPH BLOCK INSTRUMENTS AND BELLS

the latter is at "danger," the ground arm stands in a position which causes it to engage with a cock on the brake-pipe at the head of the train, thus automatically applying the brakes if the driver overshoots the signal. Train-stops of this description are in use by the underground railways of London and other electrically worked lines [27], but the trip arm on the coaches will only act if it be set properly. The practice is for the arm on the leading motor-vehicle to be set on departure from the terminus, which, of course, means that the process has to be repeated at the end of each journey, when with motor-trains the last vehicle becomes the first on the return journey. Failure to observe this precaution will cause the train-stop to become inoperative. At the time of writing, a train-stop applicable to conditions of steam traction does not appear to be invented.

Track-circuits and Safety. The scope of track-circuits is, however, far from being confined to rendering the fixed outdoor signals automatic. In lock and block working they may be substituted for treadles between the home and advance signals, thus removing the only weak feature, as already alluded to, in an otherwise excellent method for protecting trains. They also better fulfil the functions of "train-protection bars," and other mechanical or semi-mechanical devices for placing a check upon the actions of signalmen, and rendering it unnecessary that, in accordance with Rule 55, the fireman or guard of a detained train should go to the signal-box to remind the signalman of the position of the train or engine. The Midland Company has gone in largely for track-circuit protection, and where it is installed its signals now bear a white enamelled diamond-shaped board just below the arm. This signifies that no one need go to the signal-box to remind the signalman. But where a plunger is provided at the signal-post, which the fireman can actuate instead of going to the box, the post bears a board shaped thus: . Where there is no indication the fireman, guard, or shunter, as the case may be, must go to the box in accordance with Rule 55. The utility of track-circuits also extends to *approach locking*—namely, the presence of a train in section can be made to hold points at any required distance ahead until the train has passed over them. To sum up, track-circuits unquestionably form the most important contribution towards the attainment of safe railway working yet devised.

Power Signalling. Various systems of "power signalling," so called, have come to the fore since 1896, enabling signals and points to be operated by some form of power, instead of by the manual force of signalmen. Early in the 'seventies Mr. W. R. Sykes took out the first patent for operating signals by power, and in 1875 he installed the first power-worked (electrically) signals in the world, at the entrance to the Sydenham Hill Tunnel on the Chatham Railway [26]. The first large power interlocking plants were, however, those set up (in 1897) at Spitalfields Goods, Great Eastern Railway, and at Crewe. As with the manual system, it is necessary to have levers interlocked with each other, and with some power systems the mechanical levers are retained in miniature, hence the signalman has nothing new to learn in the way of movements. The interlocking frame of a power installation, of course, is much smaller and more compact, and it is possible to interlock points and signals by return connections to the levers. Therefore, the signalman, after moving a lever, is made aware whether the point or signal has answered the lever. It will be understood that the result of pulling or releasing a lever is merely to transmit power for the purpose of actuating a motor adjacent to the points or signal itself, this motor performing the required movement of the points or signal. The connections between the signal-cabin and the motors are invariably laid underground, thus eliminating the risk of employees tripping over exposed gear, in the form of wires and rods. Moreover, with underground connections, the mechanism itself is less liable to accident, neither can it get clogged with snow, ice, or dirt.

Train-movements can be carried out much more rapidly by means of a power installation than with a manual plant. With the former the levers are nearer together, and the physical effort of moving them is infinitesimal. Also it is claimed that the automatic return indication relieves the signalman of mental strain, so that not only can one power signalman do the work of three manual operators, but he does it with less expenditure of nervous force. The Board of Trade permits facing points to be worked by power from a greater distance than manually. But while power signalling effects a considerable saving in working and maintenance expenses, the higher initial cost precludes its adoption except at very busy centres. Among the different systems now in use are the McKenzie-Holland and Westinghouse electro-pneumatic (normal pressure), installed on the Great Eastern, North-Eastern, Caledonian, Lancashire and Yorkshire, and Metropolitan District railways; the electro-pneumatic (low pressure), used by the London and South-Western and Great Central; the "Crewe" all-electric, employed by the London and North-Western; the Siemens all-electric, adopted by the Great Western; and the Sykes electro-mechanical, found on the Brighton, South-Eastern, and Glasgow and South-Western railways.

Power Signalling on a Large Scale. The signalling of the Glasgow Central Station, Caledonian Railway, may be described as the most up-to-date example of power signalling upon a large scale. This vast traffic centre is controlled from one signal-box [36], which was brought into use May 3, 1908. The locking frame is 83 ft. long, and contains 374 levers, which is larger than any purely mechanically or purely power-worked frame in the world. The system is the McKenzie-Holland-Westinghouse, in which the points and signals are actuated by motors operated by air compressed to a pressure of about 70 lb. per square inch, the valves of the motors being opened and closed electrically by circuits controlled by the movements of small levers in a miniature locking frame. The points are actuated by the usual electro-pneumatic method—the switches, plunger, and locking bar all being worked by one movement, the full stroke of the lever not being attainable until the return indication has been obtained that the lever has done its work.

In addition to this there has been provided a further safeguard by the introduction of "constant detection." The virtue of "constant detection" is that a signal cannot be cleared, or, if cleared, is put to danger by the disarrangement of the points due to any cause after the points have assumed a proper position by the movement of their respective levers. This is accomplished by a special electro-mechanical device forming a part of the point-lever mechanism working in conjunction with detecting apparatus situated at the points and in direct connection with the levers themselves. If a pair of points is trailed through, rendering them

unsafe for traffic, or if their position does not correspond from any cause with that of the lever by which they are controlled, the device above referred to operates so as to put the signal to danger, if it has been previously cleared, or to prevent the signal being cleared in case its lever should be operated.

Route Indicators. A large reduction in the number of signal-arms has been obtained by the use of route indicators, which bear upon them the number of the platform or road. Under the arms or by the side of the posts is a case containing slides, all of which bear numbers corresponding to those of the roads the signal leads to. The case also contains a shutter, which is normally down when the signal is on. For instance, from No. 3 down line it is practicable to run into nine out of the thirteen platforms of the station, but there is only one arm. A train wishes to be admitted to one or the other of the nine platforms. The signalman would first "set" his road for the selected platform, and then pull over the corresponding lever, which would cause an electric current to flow to the indicator case and withdraw the lock from the slide bearing the number of the platform in question. The current would flow to the magnet of the motor which would cause the slide to be lowered, and then to the motor that would lower the arm and raise the shutter. If the platform were not fully clear, the signalman would pull over the lever, which would lead to practically the same movement, except to lower the arm.

Fog-signalling. We now turn to the problem of signalling during foggy weather and falling snow, when the outdoor signals are obscured from vision. A primitive procedure, still very widely practised, consists of stationing men at the signal-posts to place detonators on the metals, the explosion of which, under the leading wheels of the engine, tells the driver of a "danger" indication. The *detonating fog-signal* was first introduced by Mr. E. A. Cowper, M. Inst. C.E., somewhere about 1841 or 1842, and in 1844 it was recommended by General Pasley, Inspector-General of Railways, for general adoption. This signal now consists of an outer and inner dome of tin and a circular base-plate. On the base-plate in the centre is soldered a triangular-shaped piece of metal, on which are three nipples. Percussion caps are placed on these nipples to fire the charge of black powder. A recess for the nipples obviates the danger of premature explosion. There is also a duplex detonator, with two separate explosive chambers, absolutely independent of each other, rendering it no longer necessary to place two signals on the rail as a precaution. The detonator is bound to the rail by a strip of tin.

31. TRACK RAMP FOR CAB SIGNALS

Fog-signalling with hand-placed detonators is rather a fallible device, and a risky occupation to boot. To facilitate the work of the "foggers," it is usual to have miniature signals on the ground, which are mechanically or electrically connected to the real arms.

Fog-signal Pits and Machines. Some lines, notably the Great Eastern, have tried sinking pits between the tracks at busy places, and placing the signal repeaters and fogmen in them. This was, however, found dangerous to the men, in that the detonators exploded on a level with their faces.

Many types of fog-signalling magazine machines have been placed on the market, designed to render it unnecessary for the fogmen to cross the rails in order to place the detonators on the line he is signalling, and at the same time to facilitate the fogging of two or more lines by one man should circumstances allow. Of this type is the "Premier" machine, supplied by the Railway Signal Company, with a capacity for exploding eighty or more detonators as required without recharging. The detonators are placed under a punch, which is fixed on the outside of the rail, and is slightly raised above rail-level by the detonator being placed under. This operation is done by pulling the lever over. The tyre of the wheel depresses the punch, and so explodes the detonator. Frequently the cause of the failure of a detonator to explode is traced to a skidding wheel, which pushes the detonator off the rail. By this invention the detonator is not placed on the line, and consequently that danger is removed. The exploded detonator is removed from under the punch by the man placing the lever in the normal position, and a new detonator is automatically placed in the holder at the end of the stroke of the lever. Should, however, the detonator not be required for explosion by the train for which it was placed, it can readily be removed by the lever being placed in the mid-position, and can be placed under the punch a second time, when desired.

However, fogs and snowstorms are apt to come on suddenly, and between the time when the fogmen arrive on the scene there is the risk of drivers running past danger signals, in default of hearing a detonator explode. To meet this danger, an apparatus has been devised whereby a signalman can place a detonator on the line without moving from his box. Automatic fog-signalling machines on these lines are now installed on the District Railway. They are worked by air motors in accord with the automatic track-controlled signals. In normal working the apparatus is out of use, but it is switched into play from the nearest station directly a fog comes on. The magazine contains fifty detonators, and when the stock drops below a certain limit the machine starts whistling to be replenished, and continues its lament until its needs are attended to.

Engine-cab Signalling. But, when all is said and done, the most efficacious solution of the fog and other kindred problems is some method of automatically repeating the indications conveyed by the outdoor signals direct to the cab of the locomotive, where the enginemen cannot fail to see or hear them. Till comparatively recently all of the many inventions which aimed at achieving this object sought to do so by purely mechanical means, such as fixing a lever alongside the track, so that while the corresponding signal stood at "danger" it would catch against an arm projecting from the locomotive, and the resultant impact would cause either a bell to ring or a whistle to blow, or would actuate a miniature semaphore on the engine. But the weak point of any such system at once occurs to the mind. The force of the blow set up by such a weighty body as a moving train is so tremendous that the pedals or triggers thus arranged are liable easily to be thrown out of gear.

Electric Cab-signals. That the best solution of this difficult problem is by recourse to electricity was realised some years ago. One of the first apparatus embodying this principle was Boult's *induction cab-signal*, which was tried on the Great Central Railway about fifteen years ago. Its essence was the establishment at the side of the line of a magnetic field, proportioned in length to the average speed of the trains passing the spot. An armature attached to the locomotive was carried through the magnetic field in the close neighbourhood of, but making no actual contact with, the magnets. In this armature there were independent needles, which, being deflected by the electric current set up by the magnets, made a contact, and so rang a bell to call the attention of the men on the footplate. The use of this cab-signal was only discontinued because the line in question was used by the engines of other companies who objected to fitting their engines for it.

An ingenious and reliable cab-signal of the audible type [39] has lately been adopted by the Great Western Railway, where it is used, by permission of the Board of Trade, as a substitute for fixed visual distant semaphores. Under this system the driver receives either a bell ("clear") or whistle ("caution") signal in his cab, instead of having to rely upon sighting the distant signal. Therefore, the system offers the additional advantage of being in constant use, and so guards against possible forgetfulness of drivers even in clear weather. The cab-signals are brought into play by means of a ramp [31] between the rails and a contacting device or shoe carried underneath the engine. Whenever the engine passes over a ramp the shoe is forced upwards. When it is desired to give the "caution" signal the ramp is left "dead"—that is, uncharged with electricity, and the lifting of the shoe mechanically destroys a local electric circuit on the engine, causing the whistle to sound and a red-coloured shutter, inscribed "danger," to appear in an indicator inside the cab. When it is desired to suppress the normal "caution" signal, the signalman moves a special lever in his cabin, which causes the ramp to be energised with electricity. The shoe now picks up current from the ramp, with the result that the "caution" signal is restrained, and an electric bell, indicating "line clear" begins to ring instead.

The outstanding feature of the apparatus is that, as the operation of the "caution" signal from depending upon the raising of the shoe is mechanically infallible, while the suppression of that signal depends upon the successful picking up of electric current, neither dirt, frost, snow, nor electrical failure can prevent the operation of the more important indication. The worst that can happen is for the "caution" signal to be given in error.

The apparatus has stood the test of heavy snowfalls, when it was found necessary to abandon the use of the semaphore signals owing to their being clogged with snow. Some of the engines fitted with the apparatus have a hollow arm, which can be heated by steam to melt snow and ice congealed on the ramp.

Another ingenious cab-signal has been adopted by the North-Eastern Railway [28]. It is the invention of Mr. V. L. Raven, the company's chief mechanical engineer, and is designed to pick up indications by the rubbing of metallic brushes carried on the engine over metallic bars placed in the track. This method of collection, however, is not essential to the system, since it is capable of acting equally well without direct contact, by causing electro-magnets on the line to influence magnets on the engine. The system employs both visual and audible cab-signals. The former are conveyed (1) by a miniature semaphore, whose position indicates the condition of the line ahead as shown by the home and advance signals; (2) by two needles, deflecting to numbers 1 and 2 and 3 and 4 respectively. These latter are route indicators, and inform the driver which road he has to take at a diverging junction of four ways or less. Thirdly, there is a failure indicator in the form of a small grid, through which a white light shines whilst the system is in operation, and a red light if it fails or is cut off. The audible signals, which are merely to call attention, are given by a bell. The line "distant" signal plays no part in the system, and may be dispensed with if desired, for the electrical signalling point can be installed at any distance from the signal-cabin. On the route indicators a straight-through point is signalled as Number 1. If, while a train is halted at the home signal, the signalman wishes the driver to draw up close to his box in order to speak to him, he can so manipulate his levers that the cab semaphore will work up and down, and the bell ring intermittently. This cab-signal has been in use for several severe winters without experiencing any difficulty from ice. It was originally an "open circuit" system, but is now a "closed circuit" system. The action of the apparatus is of the simplest possible character, the main principle being the invariable operation of the apparatus at certain points, by the natural action of certain parts, without the aid of either signalman or driver, and the subsequent continuance of the indications resulting from the natural operations, until they are stopped or reversed by the action of the signalman.

The Richmond branch of the North-Eastern Railway has recently been equipped for cab-signalling, and it has been arranged that upon this branch no engines other than those fitted with the Raven apparatus shall run.

Staff and Tablet Working. The regulation of the traffic on single-line railways is accomplished either by an electrical train staff or tablet apparatus. A staff or tablet, suitably inscribed, is delivered to the engine-driver at station A, and constitutes his authority to occupy the main track between A and B. On reaching B, he surrenders the tally, and receives another one, which gives him the right to the road between B and C. The tallies, in any desired numbers, are kept at each of the two stations, and are locked in a cabinet, automatically controlled through electromagnets, by an apparatus in the cabinet at the other station. And, a staff or tablet being taken out at one station, a second one cannot be taken out at either station until the first one has been returned to the magazine at one station or the other. Thus, to get two trains in the same section at the same time is impossible. One line wire is sufficient for all purposes—namely, operating the staff or tablet instruments, giving code signals on bell, and for telephonic communication. When it is required to work permissively a single line equipped with the staff apparatus the following method can be adopted with perfectly safety. Each staff can be made up of three portions coloured distinctively. The end portions, coloured red and blue respectively, are denoted as "tickets"; while the centre and fundamental portion, coloured yellow, is called "staff." When it is desired to send three following trains from station A to station B, an entire staff is withdrawn from a magazine [37] in the ordinary manner. The first and second driver each take a ticket and see the staff. The third driver

SAFEGUARDS FOR THE TRAVELLING PUBLIC

32. TABLET EXCHANGE —RECEIVER

33. TABLET EXCHANGE —DELIVERER

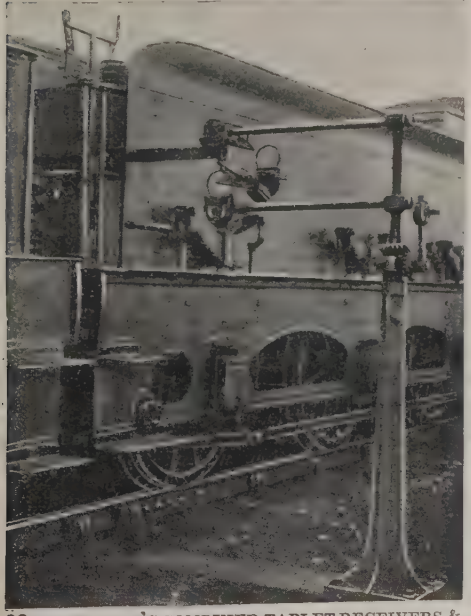
WHITAKER'S ELECTRIC TOKEN EXCHANGE

34. TABLET RECEIVED

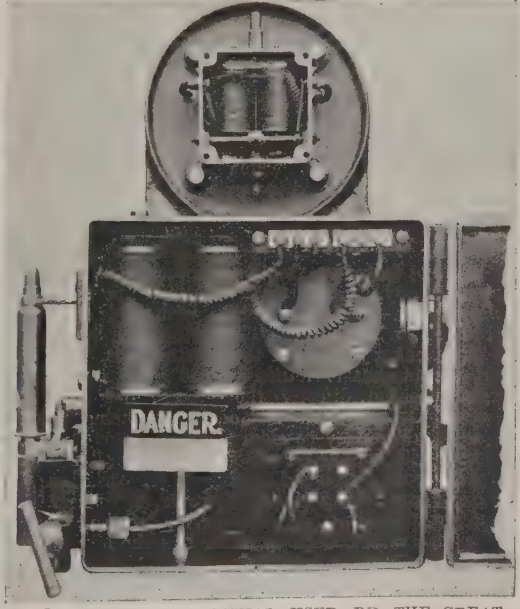
35. READY TO RECEIVE

36. THE LARGEST POWER INTERLOCKING FRAME IN THE WORLD, AT GLASGOW CENTRAL STATION

37. ELECTRIC TRAIN STAFF MAGAZINE



38. WHITAKER'S COMBINED TABLET RECEIVERS & DELIVERERS ON ENGINE AND ALONGSIDE TRACK



39. AUDIBLE CAB-SIGNAL USED BY THE GREAT WESTERN RAILWAY—INTERIOR OF CAB INDICATOR.

will take the staff. It is physically impossible to replace the staff in either instrument until the three portions are screwed together, and until this is done both instruments remain locked.

Exchanging Apparatus. On some lines, in order to avoid stopping at signal-boxes to discard one tally and pick up another, what are called staff "catchers," or tablet "snappers," are employed. A "catcher" [32] usually denotes an apparatus for exchanging the full-sized staff instruments, which are especially equipped with ring-handles. It is a very simple contrivance. By the side of the line is fixed a post, with an arm projecting to the driver, and shaped to receive the staff for the section the train has just passed through. A driver hangs the staff by its handle on to this arm, which projects from a leather-padded target, in order to absorb the force of the blow. A few yards farther on is another post with a pocket [33], into which is placed the staff for the section in advance. The driver plucks his staff as he passes the post. At night the target-arm and fresh staff are made prominent by means of lamps, carried on a separate post in the case of the former, and braceted to the second staff-post. With this exchanging contrivance a train need slow down to only 20 miles per hour.

It has long been customary to exchange electrical train tablets, which are small metal discs, at higher speeds by hand. The tablets are placed in leather pouches furnished with wire hoops, and through the latter the driver and signalman respectively thrust their arms as the train speeds by. But the practice is a somewhat risky one, hence several automatic tablet exchangers have been devised.

Whitaker's Tablet Exchanger. A very ingenious "exchanger" [38] has been invented by Mr. A. Whitaker, and is in use on the Somerset and Dorset, Midland and Great Northern Joint, and Colonial railways.

The locomotive tender is equipped with a catcher which slides in and out in a bracket, and is thrown out when it is required either to catch or discard a tablet. The aluminium tablets are placed in leather pouches furnished with rings. By the side of the track are placed columns having one or two different kinds of arms, according to whether the column in question is for setting down, picking up, or exchanging tablets. If the last-named, two arms are necessary, the upper one being the setting-down arm, and a replica of the fish-tailed catcher on the tender, the jaws of which have three triggers. A tablet to be discarded is carried in a slot at the back of the tender catcher, and is snapped off by the ring passing through the jaws of the catcher by the side of the track, while a tablet to be picked up is hung from its ring on another arm, and snapped up by the tender catcher. The arms normally stand in—that is, are parallel with the track—and when to be used are thrown out by levers. An outstanding feature of the apparatus is, however, the automatic return of the arms to the normal position directly the process has been effected. Otherwise, the fact of the arm being left to project diagonally so close to a train would be attended with serious risks. The "snapper" performs its work at a speed of sixty miles per hour.

In one particular instance, however, it was not found practicable to place a receiver by the side of the track; it had to be located in the six-feet way, thus necessitating a special design. With this type of receiver the arm is set vertically [34 and 35] for an approaching train, and drops down vertically —backwards—instead of revolving horizontally, directly the catch off the tender is effected.

In many cases, by the use of electrical train staff and tablet instruments, together with exchanging apparatus, the facilities for working the traffic are so improved that the doubling of single lines and the consequent capital expenditure has been indefinitely postponed.

The Training of Signalmen. As a rule, the selection of candidates for the post of signalman, together with the training and allocation of signalmen, rests entirely with the traffic department. The practice observed in the main by all companies is to appoint youths between fourteen and sixteen years of age as lad porters, and those among them who wish to become signalmen are encouraged to learn single-needle telegraphy. Again, a lad between the ages named may join the company's service as telegraphic messenger, earning between 6s. and 14s. per week, and at once devote himself to learning the use of the single-needle instrument. A sharp lad will be able to receive and transmit telegraphic train messages in from four to six months' time, and when he has demonstrated his ability he is placed in a large signal-box to act as telegraphist or train boy. Here his duties are to read and transmit telegraphic messages, and to write up for the signalmen the train books that record the times at which every train is accepted into and clears the block section. While acting as train boy, a youth soon gets thoroughly acquainted with the working of the block telegraph instruments, the diagram of the line, and interlocking. Some companies keep train boys until they attain twenty years of age, and then allow them at once to pass the examination by the district superintendent for promotion to third-class signalman. Others, however, relieve the lads of their duties at seventeen years of age, and compel them to revert to porters, lamp-men, shunters, or clerks for a period of three or four years. This latter rule holds good with companies which will not appoint a man a signalman until he attains twenty-three years of age.

When a man who has not previously acted as train boy, or learnt single-needle telegraphy, wishes to qualify for a signalman, he is not allowed to take any steps to carry out his desire until he has been in the company's service for a period of six months. The procedure is then to despatch him in his original capacity, as porter, shunter, or clerk, to some small station, where his ordinary duties are sufficiently light to enable him to learn the practice of signalling and single-needle telegraphy. It is not every company that insists upon the would-be signalman qualifying as a telegraphist, but a man not so qualified could never hope to rise above the rank of third-class signalman on a remote branch line. The same procedure is observed by the companies alluded to above, which do not allow train boys or boy telegraphists to continue as such till they come to the limit of age for promotion to signalmen.

The Complete Signalman. Having acquired a fair knowledge of signalling in a way-side signal-cabin, an aspirant is promoted to a more important station, where, besides fulfilling his ordinary duties, he is put on to relieve for a few hours at a stretch a fully fledged signalman. Lastly, when a vacancy occurs, a man who thinks he has mastered the subject may apply to be examined for third-class signalman, by the district traffic superintendent or signalling inspector, according to the company's practice. The examination is of a searching character. It generally comprises both oral and written examination

in the working of the block system, any patent method of signalling, such as the "lock and block" and electric train staff or tablet system, which may be adopted by the company in question, and "emergency" signals, or what to do in a dozen or more different kinds of mishaps.

Signal-boxes are classified as belonging to principal main lines, secondary main lines, and branch lines. In each of these divisions there are three different grades of signalmen—namely, third, second, and first class; and with some companies there are two higher grades on principal main lines —namely, "special" and "extra special."

Pay and Promotion. The rates of pay vary not only according to class, but also according to division. Thus, a third-class signalman on a principal main line earns more than a first-class man on a secondary main line. Signalmen earn from 18s. to 25s. a week, and receive for correct working a bonus of from £2 to £5 per annum. All vacancies are posted among the men, and each man has a chance of applying for promotion, which is decided by seniority and merit. When a man is promoted to a fresh box he is allowed a fortnight or so in which to learn it to the satisfaction of his superintendent before taking charge. Each signalman is responsible for his own block telegraph instruments, and his first duty after signing on in the train register book is to satisfy himself that all the electrical instruments, signals, and points are in good working order. An adjusting apparatus enables him to adjust his signal-wires for expansion and contraction from heat or cold without leaving his cabin, while the *point-rod compensator* automatically compensates the rods which actuate the points. The signalman is responsible that his signal lamps are lighted and extinguished at the regulation hours and that they are lighted in foggy weather or during falling snow, but the lamps are trimmed, placed in position, lighted, and extinguished for him by porters or lamp-men.

A signalman's hours are never longer than twelve, and that only on unimportant branch lines, from eight to ten hours being the rule elsewhere. Where the work is heavy more than one man is put in a box, and when the telegraph work is heavy a telegraphist also is allowed. The stationmaster supervises the duties of the signalmen at his station, and must frequently visit the signal-boxes for the purpose. Every signalman is examined from time to time in all emergency working by his stationmaster and inspector.

Railway Signalling School. In order to give every employee who so desires an opportunity of acquiring a knowledge of signalling and outdoor railway working, and to avoid the necessity of men going into signal-boxes for that purpose, several companies have established signalling schools. The equipment of these schools comprises a model railway, with main and branch lines, junctions, refuge sidings, cross-over roads, etc. This model railway is fully signalled and provided with facing-point locks and bars, fouling bars, discs, detectors, and other equipment. The whole of the signals and points are worked from a lever frame, properly interlocked. There are complete sets of train-signalling instruments and single-line electric train-token apparatus connected in pairs. These schools are placed in charge of an instructor, who conducts classes.

Department of the Signal Engineer. When men are promoted from being signalmen, they usually go to the traffic department, becoming platform inspectors and rising to district traffic inspectors. The maintenance of the complicated array of signals, interlocking apparatus, and electrical instruments is a work of great magnitude. It is entrusted to a signal engineering department, which has nothing to do with the training of signalmen or manning of the boxes. The work of the department is divided into a mechanical and electrical side. To begin at the bottom, there are signal and telegraph linemen, who are responsible for the maintenance of a certain number of boxes, which they visit periodically according to roster. The signal linemen clean and oil the fittings of each signal and point, and execute any small repairs or renewals that may be required, but they are not allowed to tamper with the interlocking apparatus or to take in hand any important repairs or renewals. Signal fitters come round at less frequent intervals to overhaul, test, and clean the interlocking frames, facing-point locks, and other parts, while heavy repairs and renewals are carried out by an extra gang attached to each district, in charge of a responsible foreman. The telegraph linemen, however, are considered competent to overhaul the block telegraph and all other electrical instruments, in addition to recharging the batteries and mending broken circuits. These men maintain the Post Office wires under an agreement between the Post Office and the railway company. For the purpose of maintenance the whole line is divided into districts, each of which is in charge of both a telegraph and signal inspector. A special department often exists for carrying out new works, under the superintendence of a new-works inspector, who acts directly under the head office. The whole organisation of maintenance is vested in a managing staff, which comprises electricians, draughtsmen, assistants, and clerks, all of whom are employed under the control of the chief of the signalling department.

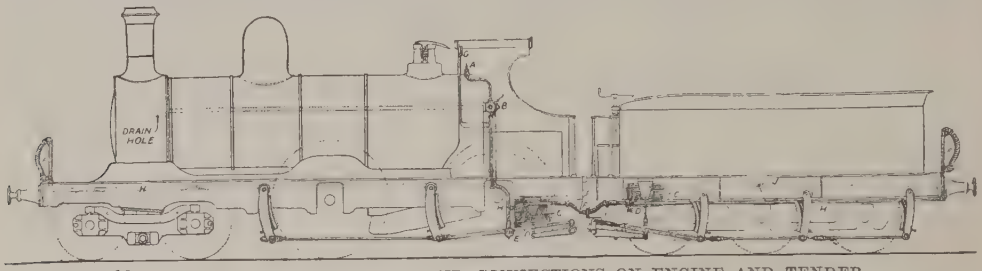
Railway Brakes. A fact little realised by ordinary railway passengers is that the attainment of the present high speed of our trains was made possible only by inventions of suitable means of controlling them. In itself, the ability of trains to travel at high speed would have been not only a useless but a dangerous thing had it not been accompanied by such improvements in railway brakes as enabled drivers and guards to control the tremendous energy set up by heavy trains travelling at high velocities.

The history of railway brakes is a long and complicated one, which cannot be related here. Suffice it to say that the continuous automatic power brake, the compulsory equipment of which to all passenger trains was brought about by the Railway Regulation Act of 1889, was gradually evolved from the hand-operated screw brake that formed the earliest method of retarding the motion of trains.

The basis of a continuous automatic power brake is an apparatus fitted to each wheel of every vehicle composing a train, so that every engine, tender, and vehicle has its own store of brake force ready for instant use, while its action is such that, if every or any coupling in the train separate, the brake of each vehicle is automatically and instantaneously applied. The brake is capable of application by the engine-driver and by any of the guards.

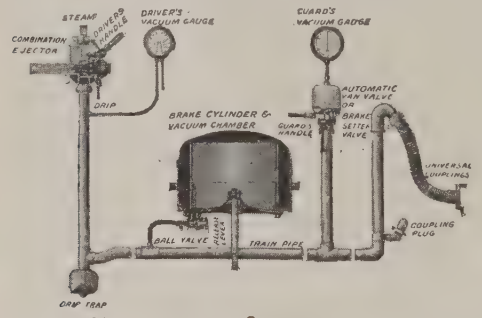
Unfortunately, British railways have been unable to agree upon uniformity of brake system. At the present day 59 companies are returned as using the automatic vacuum, and 17 companies the Westinghouse automatic air brake.

The "Ordinary" Vacuum Automatic Brake. This brake stops the train by the application of brake blocks to the tyres [40] in the same way as the ordinary hand brake. The levers, however, which apply the blocks are moved by a piston working in a cylinder, the piston deriving its power from the pressure of the atmosphere. It is continuous, each vehicle carrying its own brake cylinder, which is connected to a pipe running from end to end of the train, and through this pipe the action of the brake cylinders is controlled on the engine. A combination ejector consisting of two ejectors known as the "large" and the "small"—the latter being placed inside the former, and worked continuously, while the "large" is worked by the admission of steam—exhausts the air out of the continuous pipe and the cylinders. The brake is applied by the admission of air into the train pipe, and released by the withdrawal of the same through the ejector.



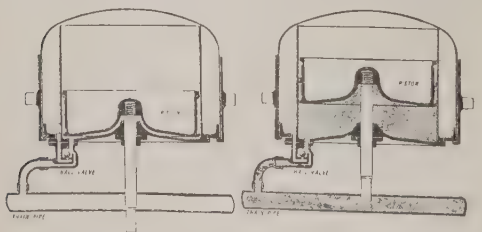
40. AUTOMATIC VACUUM BRAKE AND CONNECTIONS ON ENGINE AND TENDER

A. Steam screw-stop valve B. Combination ejector C. Brake cylinder D. Ball valve E. Drip trap F. Hose pipe and coupling G. Vacuum gauge H. Train pipe J. Vacuum chamber



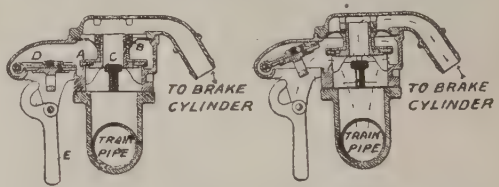
41. VACUUM AUTOMATIC BRAKE

The engine having been coupled to the train, and the hose couplings connected between the tender and train, and also between the coaches, and the one at the end of the train having being placed upon the plug, the driver admits steam to the small ejector, which soon exhausts the train pipe and cylinders to a vacuum of from 20 in. to 24 in., or the large ejector may be used if the vacuum is required to be obtained more rapidly. The small ejector must be kept at work continuously to maintain the vacuum. To apply the brake, the driver moves the handle of the combination ejector in the direction marked "On," thus admitting air to the train pipe and to the bottom of each cylinder, which lifts the pistons and so pulls the blocks to the wheels. The air cannot pass to the top of the piston, as it is prevented by the ball in the ball valve. The power of the application is controlled by the amount of air let into the continuous pipe.



42. VACUUM BRAKE "OFF" 43. VACUUM BRAKE "ON"

To release the brake, the handle must be returned to "Running position," when the air let in to apply the brake will be removed through the small ejector; or it may be released more quickly by pushing the handle in the direction marked "Off," and so admitting steam to the large ejector. The brake having been applied, the pressure of the blocks on the wheels may be increased or diminished at pleasure without removing them, and also without reducing the full reserve power of the brake, which is always at command for an emergency stop.

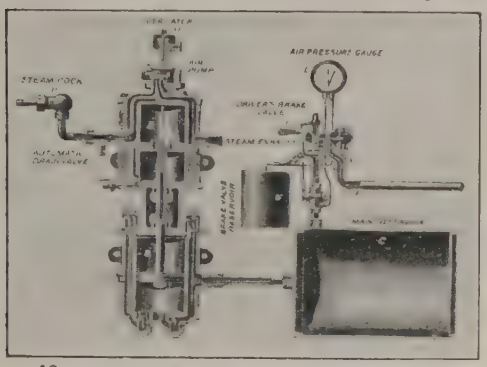


44. NORMAL POSITION OF RAPID-ACTING VALVE 45. RAPID-ACTING VALVE OPENED & BRAKE APPLIED

Ordinary stops should not be made by a violent application of the brake, but by a destruction of vacuum, say, from 5 in. to 10 in., which should be re-created slowly as the train comes to rest by placing the handle in "running position." To apply the brake quickly the handle must be moved to the position marked "On," thus fully opening the air valve [41]. The guard can apply the brake by pressing down the handle of his valve, the "brake setter-valve," thus admitting air and applying the brake throughout the train, which it will stop even if the engine remain under full steam. When a rapid application is made by the driver, the guard's valve opens automatically, letting in air from the van, thus increasing the rapidity of application, and it closes again after the brake has been fully applied.

Arrangement of Brake Cylinder and Vacuum Chamber. The brake cylinder and vacuum chamber is shown in section in **41**, self-contained in the vacuum chamber as applied to carriages, and is the only fitting required. The piston fits freely in the cylinder, and is packed with

a rolling rubber ring, which, when the piston moves, rolls between it and the cylinder, making a perfect packing without friction. The piston-rod is coated with brass and works through a brass bush, and a packing rubber prevents air from passing the rod. This rod should be kept clean by wiping with a dry cloth, but no oil or grease must ever be used. At the bottom of the cylinder is attached the ball valve, the branch of which is connected by a small hose pipe to the train pipe. This valve is of the most simple construction, as there is only one



46. WESTINGHOUSE QUICK-ACTING BRAKE. PARTS APPLIED TO LOCOMOTIVES ONLY

moving piece, and that being a small brass ball, having a rolling action in a horizontal position, has consequently no friction. The spindle with release lever is added for the purpose of withdrawing the ball from its seat when it is required to release the brake by hand—for instance, when coaches are detached from the engine. This spindle is made air-tight by a small diaphragm, the pressure on which when the vacuum is created pulls in the spindle and allows the ball to go freely to its seat

The action of the cylinder is as follows. The air is drawn out through the train pipe from the bottom of the piston direct, and from the top by passing the ball. To apply the brake, the air is let into the train pipe, and it then passes to the under side of the piston, and, being prevented from entering to the top by the ball, lifts the piston, and so applies the brakes with any amount of force according to the quantity of air let in. Fig. **43** shows "Brake on," and **42** shows "Brake off."

A drip trap is placed on the train pipe at the bottom of the down pipe from the ejector, so that any moisture will drain into it. It is fitted at the bottom with a self-acting ball valve, which opens when all the vacuum in the train pipe is destroyed, and allows the water which may have collected to run out.

Before starting, the driver must see that the gauge indicates at least 18 in. of vacuum, and that not less than this amount is maintained during the journey, and while standing at stations. The vacuum is created by admitting steam to the small ejector by means of the steam cock on the combination ejector. The guard also must see by the gauge in his van that the proper amount of vacuum is maintained, or report otherwise to the driver.

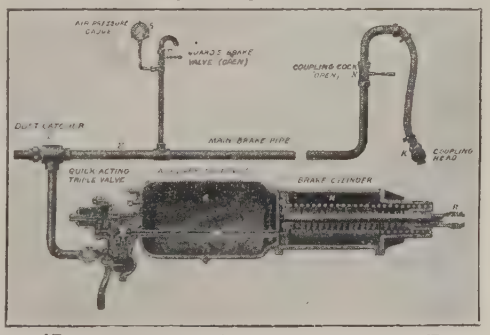
Rapid-acting Vacuum Brake. The rapid-acting vacuum brake—which can be used either as a "rapid-acting" or an "ordinary" vacuum automatic brake—consists of the addition of a rapid-acting valve. This appliance is mounted on the train pipe as near as possible to the brake cylinder, and is connected to the latter by the usual flexible hose.

The normal or "running" position is shown in **44**. A vacuum is maintained on the under side of the valve, A, and the top side of the diaphragm, B, the atmospheric pressure being free to act on the top side of the valve, A, and the under side of the diaphragm, B; but on account of an excess of pressure the valve, A, is held tight upon its seating.

When a rapid action of the brake is required, air is suddenly admitted to the train pipe and thus to the under side of the valve, A, then the pressure acting on the under side of the diaphragm, B, is sufficient to cause it to lift the valve, A, and allow air to pass full bore both to the brake cylinder and to the train pipe, as shown by **45**. Immediately the brake is "full on," the valve falls to its normal position by gravity.

To obtain a graduated application of the brake, air in moderate quantities is admitted to the train pipe, and the area of the passage around the peg, C, is proportioned so that it will allow the necessary amount of air to enter the brake cylinder, and so obtain a simultaneous action of the brake on every vehicle throughout the train.

Westinghouse Automatic Air Brake. Air pressure is the power employed for working the Westinghouse brake. Each locomotive carries its own air compressor, which is driven by the steam from the boiler of the engine, and compresses air to a pressure of about 80 or 85 lb. to the square inch, or, in the case of the quick-acting brake, to 90 or 95 lb. When the locomotive is coupled to the train, this compressed air, with which the main reservoir has been charged, is turned on to the main pipe running through hose coupling the whole length of the train, and thence through branch pipes leading to auxiliary reservoirs carried by each carriage. Thus, when the train is ready to start, the whole system of reservoirs and pipes is charged with an equal pressure of air, which is ready at any moment to act instan-



47. WESTINGHOUSE QUICK-ACTING BRAKE. PARTS APPLIED TO TENDERS AND CARRIAGES

taneously upon the brakes by means of a device known as *the triple valve*. The following advantages and principles of operation are secured by this method of employing compressed air: (1) The power is continuous throughout the whole length of the train, and can be applied to all vehicles either by the driver from the engine or by the guard from any part of the train. (2) The action is automatic, instantaneous, and simultaneous. It applies itself with full force to every vehicle should the train separate or should a rupture of a vital part of the apparatus occur. (3) The brakes are

applied by a *reduction* of air pressure, purposely or accidentally produced. (4) The brakes are released by an *increase* of air pressure, which can be produced by the driver only by means of the air compressor on the engine.

We shall now proceed to describe in detail the operation of the Westinghouse quick-acting brake, references being made to the accompanying figures showing sections of the various parts.

Parts Applied to Locomotives. Every engine is fitted with the following parts [45]:

The *steam air pump*, A, B, which compresses the air; its steam cock, P; and lubricator, O.

A *main reservoir*, C, for storing the air necessary for releasing the brakes and recharging the auxiliary reservoirs.

A *driver's brake valve*, D, which regulates the flow of air from the main reservoir into the brake pipe for charging the train and releasing the brakes, and from the brake pipe to the atmosphere for applying the brakes.

Parts Applied to Tenders, Carriages, and Vans. A *triple valve*, F, by means of which the instantaneous action is produced, in conjunction with a *reservoir*, G, in which is stored the compressed air for applying the brakes.

A *brake cylinder*, H, with pistons and rods connected to the *brake levers* and *blocks*.

A single line of pipe, E, called the *brake pipe*, extending the whole length of the train.

Each van has a valve or cock, T, connected to the brake pipe, and a gauge, S, to indicate the pressure of air. By opening his valve a guard can stop the train, even against the will of the driver, if necessary.

Operation of Brake. The pump [46] being started by opening the steam cock, P, and admitting steam to the cylinder, air is forced from the cylinder, B, into the main reservoir, C, which is connected to the driver's brake valve, D.

When a train is to be charged—the hose couplings between the carriages having been united and the engine connected to the train—the compressed air stored in the main reservoir, C, is turned into the brake valve over to the left. It then fills the brake pipe, and flows through the branch pipe on the engine and tender and each vehicle to the triple valve, F [47], thence by a groove, and past a piston into a reservoir, G, where it remains until the brake has to be applied. Uniform air pressure then exists throughout the train, except in the brake cylinders, H, the brakes being off; and the pressure per square inch is shown on the gauge, L, connected to the brake pipe.

So long as this pressure is maintained, the brakes are kept off, as the passage from each reservoir to its cylinder remains closed by the slide valve; but letting the air escape from the brake pipe causes the triple valve pistons and slide valves to move towards the left, and to uncover the passages to the cylinders. The air stored in the small reservoirs, G, then flows into the cylinders, H, and forces out the brake pistons and rods, thus applying the brakes. From the foregoing it will be seen that the driver can, by turning the handle of his brake valve, reduce the pressure in the brake pipe, and thus apply all the brakes.

Releasing the Brake. The brakes are taken off by reopening the passage from the main reservoir, through the driver's valve, and thus restoring the pressure in the brake pipe; this moves the triple valve pistons towards the right with their side valves, and places the cylinders, H, in communication with the atmosphere by means of the exhaust cavity in each of the valves; the air used in the cylinders is thus allowed to escape, and the brake pistons and rods are pushed back to their places by springs inside the cylinders.

The driver's valve, D, shown in the diagram [46] is of the improved construction, with equalising arrangement. A small reservoir, U, is coupled to the nipple on the left of this brake valve.

Emergency Stops. The description so far explains the ordinary use of the brake. In an emergency, when the shortest stop possible is required, the brake-valve handle should be thrown full over to the right, which movement lets out the air quickly from the train pipe. This sudden reduction of pressure makes the first triple piston and slide move the full stroke, with the effect that some of the air from the train pipe, together with the air from the reservoir, passes direct to the brake cylinder, H. The reduction thus made in the train pipe helps the next triple valve to start, and so on to the end of the train. This action is so rapid that the brake is actuated by the driver in 2½ seconds to the end of a train of 50 vehicles, not less than 1500 ft. long.

The release of the brakes is made as previously described. The triple valve-cock plug [47] and handle, Z, have three positions. When the handle is down, the triple will be in ordinary or quick action; when half-way, it is cut out; and when right up, in ordinary action only.

The ordinary Westinghouse brake, which works on the same principle but carries a simpler form of triple valve, is used where emergency short stops are not likely to be required. The high-speed brake is an improvement on the quick-acting brake, invented in order to graduate the high pressure between brake blocks and wheels, so that this shall be gradually reduced as the train slows down, thus preventing skidding and undue wearing of the wheels. It carries a reducing valve, which gradually reduces the pressure as the speed decreases.

Failures of the quick-acting automatic brake are invariably on the side of safety. Here is a typical incident. On one of the hot days in the summer of 1911 a Great Central train booked to run 20 miles from London before making its first stop suddenly came to a standstill. Nobody had applied the brake. It was found that one of the brake hoses was charred to such an extent that a hole was burned in it, and the result was an automatic application. But what had ignited the indiarubber? Investigation revealed that a pane of glass in the roof of Marylebone Station had acted as a burning-glass, and that the breeze set up by the motion of the train caused the charred hose to continue smouldering till it was burned through.

Evils of the Dual Brake System. The dual brake system is a fruitful source of inconvenience, increased dead-weight, and additional cost, and sometimes, indeed, of danger to the safe working of a train as well. Nearly every Anglo-Scottish express train has to be equipped with both the vacuum and air brakes, because the English companies concerned use the former, and the Scotch the latter. Further, most of the railways are compelled to have a number of passenger train vehicles, such as family saloons, horse-boxes, and carriage trucks, fitted with both systems of automatic brakes for the purpose of working through to "foreign" lines, while, again, companies which favour the vacuum brakes are bound to keep a number of engines fitted with Westinghouse apparatus, and vice versâ.

H. G. ARCHER

How Line and Half-tone Blocks are Made. Photo-lithography. Reproduction in Colours. Collotype and Photogravure.

PHOTO-ENGRAVING

THE term *photo-engraving* comprises all methods of reproduction for printing in which photography takes the part of the artist in the older and more costly processes, such as engraving on wood and steel, or drawing on stone. The various methods used for the production of newspapers, books, picture postcards, etc., can be classified as follows: (1) Line process; (2) half-tone process; (3) photo-lithography; (4) three-colour process; (5) collotype; (6) photogravure.

Making Line Blocks. The first of these is the most simple. It is used for the reproduction of pen and ink sketches, and such prints or drawings as contain only black and white, with no intermediate half-tones. The original print is put on a copying board in front of a camera, and a negative is made in the ordinary way [see PHOTOGRAPHY]. In making a line negative, it is necessary that the lines should be perfectly transparent, and the background as dense as possible. For this purpose, the old-fashioned collodion or wet plate process is recommended, as it gives crisper and sharper lines than dry plates do, owing to the thickness of the gelatin in the latter. Collodion is prepared by dissolving pyroxylin (guncotton) in a mixture of ether and alcohol, the proportion of which is governed by the weather (about 200 grammes of pyroxylin, 20 grammes of ether, and 20 grammes of alcohol). In summer, for instance, more ether will have to be used, as it evaporates very quickly. To this solution is added a quantity of iodide and bromide salts (about 70 grammes ammonium iodide, 25 grammes of cadmium bromide and about 20 grammes calcium chloride). The collodion thus prepared should be allowed to ripen for a few days. It can be obtained ready mixed.

Sensitising and Developing Collodion. A glass plate is then carefully cleaned by immersing in weak nitric acid, and polishing after drying with a chamois leather and a paste of prepared chalk and methylated spirit. The edges are coated with indiarubber dissolved in benzol, to prevent the film peeling off. The collodion is then poured on to the plate, drained off at one corner, and gently moved about to allow the ether and alcohol to evaporate [1]. Whilst still slightly moist, the plate is immersed in what is called the silver bath, a solution of nitrate of silver in water, to which a few grains of nitric acid and iodide of potash have been added. As this makes the collodion sensitive to light, it is essential that this operation should be carried on in the dark-room. The silver bath should also be kept covered.

The exposure is regulated by the nature of the original; thus, under-exposure will cause the lines to spread, whilst over-exposure will cover them up, so that it will be impossible to get a clear print of the negative. After exposure, the plate is developed with a protosulphate of iron solution in water, of which the following is a formula: 64 oz. water, 4 oz. iron sulphate, 4 oz. acetic acid, 1 oz. to 4 oz. alcohol. Methylated spirit has been added to make the developer flow over the plate, as the latter is rather greasy and repels water. Acetic acid is also contained in the developer; it clears the image and prevents scum forming on the surface. After washing, the plate is fixed with cyanide of potash or hyposulphite of soda.

Intensifying and Printing. To make the background denser, the negative is intensified by immersing it in perchloride of mercury solution, and blackening it afterwards with ammonia if the lines are delicate. If they are fairly coarse, a solution of equal parts of bromide of potash and sulphate of copper in water can be used, and after washing, nitrate of silver solution. This intensifier is more powerful than the previous one, and gives the operator a better chance of rectifying mistakes. A solution of iodine and iodide of potash is now poured over the plate, which is washed and then cleared with weak cyanide of potash. This is the time to remedy slight imperfections, either in the preparation of the plate, or in the exposure. The plate is then blackened with hyposulphite of ammonia or sulphide of sodium.

The negative taken in this way is printed on a metal plate which has been carefully cleaned with pumice powder. Before this is done, another point has to be considered. The print on the metal itself would be exactly like the original drawing, consequently a print off this plate would be reversed on the paper, like an image seen in a mirror. To avoid this, the film either has to be stripped off the glass plate, reversed, and put on to another glass [this is described under Collotype], or the picture has to be photographed in the first instance through a prism, or by means of a silver mirror, which can be attached to the camera in front of the lens at an angle of 45° to it. It may also here be added that, though daylight can be used in exposing the negatives, or printing on metal, electric light is used by all the photo-engraving houses, as it is less subject to variation.

Printing on the Block Plate. We now come back to the metal plate, which is sensitised by a solution of potassium or ammonium bichromate in water, to which white of egg has been added (1 egg to 5 oz. of water, 10 grammes potassium bichromate, and a few drops of liquid ammonia). The plate is fixed on to a whirler, coated twice, and dried over a gas stove [2]. It is then exposed behind the negative in a printing frame, just as a piece of silver paper would be in ordinary photography. A few minutes are sufficient to make the albumen and bichromate on the exposed parts insoluble in water. The plate is then rolled up with a stiff, fatty ink which has been thinned by means of a volatile oil, such as oil of lavender. After letting the oil evaporate, the metal is put into cold water, and the surface gently rubbed with cotton-wool. This takes off the unexposed bichromate and also the ink adhering to it, and only leaves the coating and ink on the exposed parts—that is, the lines of the picture. The plate is now dried and covered with powdered bitumen, which sticks to the greasy ink and is dusted off

the plain parts with a camel-hair brush. It is heated until the bitumen melts and forms a protection for the picture against acid.

Etching and Finishing the Line Block. The plate is now ready for etching, but before it is put into the acid trough, the margin, back, and large open spaces in the picture should be covered up with shellac dissolved in methylated spirit, so that no acid need be wasted in etching metal which can be cut away quickly enough by machinery afterwards. For etching, the plate is put into an earthenware trough containing weak nitric acid, and gently rocked. After a little while it is taken out, and the acid-resisting surface strengthened by means of soft litho ink, with which it is rolled up; a soft nap roller is best used for this purpose. The plate is then dusted in with dragon's blood or bitumen and carefully brushed in four directions.

Rinsing under the tap will remove any particles of dust on the plain zinc, leaving only those that have stuck to the soft ink. The latter spreads slightly over the edges in the subsequent heating over a gas stove, and thus prevents the acid underbiting the lines. Care should be taken not to overheat the plate, as it will make the ink run too much. This process is repeated until the plate is etched deep enough—that is to say, till the lines stand out sufficiently from the ground to print well on the letterpress machine. All ink is then washed off with hot potash or turpentine and the plate rolled up again, this time with a very stiff ink and a glazed roller. This is done to get rid of the shoulder which has formed in getting the depth. One or two of these finishing baths are generally sufficient if the plate has been etched well. When all the shoulder has disappeared, the plate is cleaned again, the shellac scraped off the back, and the block is ready to be mounted. For this purpose all metal forming the margin or open spaces in the picture itself is cut away either by a fret saw or a routing machine, and the plate is tacked on to a piece of oak or mahogany which is afterwards planed down to the exact height of type—that is, nearly $\frac{7}{8}$th of an inch. The block is now finished. Ground tints are laid on line blocks by mechanical means before etching to give shading to them [3].

Half-tone Blocks. The next process, called half-tone, is much more complicated. It is used for pictures which have no sharp and black-and-white outlines, but a variety of tones more or less gradually blended into one another, which cannot, therefore, be reproduced by line. As the machine will only print a level surface, it is necessary to produce a block the surface of which, whilst perfectly level, must be regulated so that light and shade are expressed by a kind of grain in relief, which is very close in the shadows, and opens up as it gets lighter in tone. The simplest way to produce such a grain is to photograph it at the same time as the picture. For this purpose there are on the market so-called *screens*, which are produced by ruling lines diagonally on glass plates, then filling these lines up with lampblack, and placing two such plates together, to form a net. When photographed a short distance behind this screen, the negative will show the picture itself, cut up all over by a net which varies in strength, according to the nature of the image. Thus, on the negative the darkest parts will show a strong transparent net with tiny solid dots in the centre. This net gets thinner as the tones go lighter, till in the highest lights only transparent dots will remain in a solid net. The fineness of the grain itself is varied according to the nature of the work. For poster work, for instance, the screen will contain about 25 lines to the inch; for newspaper advertising a 50 screen is commonly used; most of the SELF-EDUCATOR illustrations are printed from blocks with 120 lines to the inch, whilst for finest bookwork 400 can be used. A photograph of aerated-water syrup tanks is reproduced in **4** in four different screens.

Exposure Through the Screen. Great care has to be taken to give the plate exactly the right exposure to light. It is best to use square diaphragms, or others with extended corners, as these give a square dot in the tones, which etches better on the metal than a round dot. It is also advisable to flash a white card in front of the picture for a few seconds, to give more body to the dots in the dark parts. It is not advisable to have the latter too black, as too much detail is lost that way. The negative is then developed, fixed, and intensified, in the same manner as a line negative. After intensification, when the negative is cleared with weak cyanide of potash, a good photographer can even improve on the original, especially if it be dull and flat, by forcing the shadows a little, or by etching those parts of the negative which lack brilliancy. A good negative should contain fine pinpoint dots in the shadows, a square dot, with extended corners that join on to the next, in the middle tones, and fairly fine, transparent dots in the high lights. If no prism or mirror has been used, the plate is stripped and reversed in the same way as a line negative, and the surface can afterwards be protected by albumen, gum, or thin gelatin solution poured over it; then it is drained and dried.

Sensitising and Etching the Half-tone Plate. The sensitising solution for the metal plate consists of fish glue, ammonium bichromate, and water; sometimes ammonia or white of egg is added. (Formula: 1 oz. clarified fish glue, 2 oz. water, 30 gr. ammonium bichromate.) The copper or zinc is cleaned very carefully with pumice powder or charcoal, coated, and put on a whirler. It is then turned slowly over a covered gas flame till the coating is perfectly dry, and exposed behind the negative for a few minutes. Then it is taken out and put into cold water, which dissolves the fish glue and bichromate where not exposed to the light. To show more clearly what the result is like, the plate is put into a solution of some aniline dye, which shows up the picture. Under-exposure makes the film come off the metal, whilst over-exposure fills up the dots in the dark parts. If rightly exposed, the plate is rinsed and dried. After this it is held over a gas flame and "burnt in." The image will at first vanish altogether, but gradually reappear, till it has reached a rich reddish brown colour in the darker parts and a silvery bluish tone in the high lights. It is then cooled off, and is ready for etching. If a black line is wanted round the picture, it can now be drawn with thin litho ink.

For etching, the plate is shellacked at the back for protection. Copper plates are etched with perchloride of iron at about 40° Beaumé; zinc plates in a weak bath of nitric acid, with some pyroligneous acid and sal ammoniac added (Formula: 5 oz. water, 6 oz. nitric acid, 1 oz. sal ammoniac, 1 oz. pyroligneous acid), to counteract the action of salts formed by the lead, etc., always contained in commercial zinc. The plate is left in this bath till a sufficient depth is reached, and the darker parts begin to open up. It is then taken out and proved on a hand press. If it is found that some parts require more etching, those that have had sufficient are covered up with litho ink, and the process repeated until no more etching is necessary.

Any spot or faults are then engraved by hand, and the plate is ready for mounting, as described above.

Photo-lithography. Photo-lithography is really a part of the half-tone process. In the ordinary way a print from a half-tone block can be made on a special transfer paper with litho ink, and then transferred on to the stone It is, however, quicker and less costly to make a print direct from the line or half-tone negative. The half-tone negative made for this purpose must be stronger in contrast than the negative for half-tone process on metal, as no subsequent etching is possible on the stone. The line negative need not be altered. Neither must be reversed, as they are not printed on the stone direct, but on paper first, which reverses them on to the stone. The transfer paper, which has a gelatin or albumen surface, is immersed in a solution of bichromate of ammonia, and then dried. It is exposed behind the negative in the usual way, and then rolled up and developed exactly like a line plate. When dry it is ready for transferring to the stone.

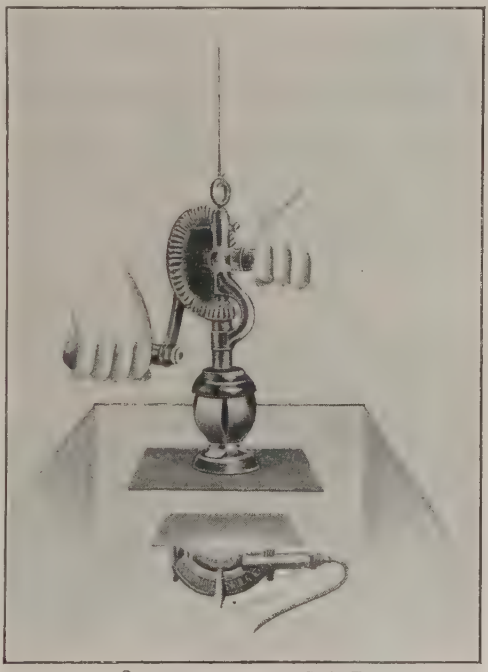
1. COLLODION COATING
Pneumatic negative holder

The Physical Basis of Three-colour Work. The next process, called three-colour work, is also a half-tone process, but, as the name indicates, has for its object reproduction in colours instead of in black and white only. Before going into the process itself, it will be necessary to explain a few things about light and colours in general [see PHYSICS, page 2587]. According to the now universally accepted theory, light is the vibration of the ether. A luminous body sends out waves of light in all directions, waves of different length striking the eye as differently coloured light. By being struck simultaneously by waves of different length, the retina receives the impression of white light, which is no single colour, but a mixture of colours. In the same way, if one series of rays be removed, the rest will strike us as one colour only.

All the spectral rays need not, however, be contained in the white light, as a suitable choice of two will give the same impression. These are called *complementary* colours—as, for instance, red and blue-green, orange and cyan-blue, etc. According to Young's theory there are only three kinds of nerve fibres in our eyes sensitive to light, and these communicate to us the primary sensations of red, green, and violet. These three colours are, therefore, called the fundamental colours. If all the three nerves are acted on simultaneously by light rays, we see white.

Pigments absorb colour rays. Now we must distinguish from light-emitting substances those which only reflect or absorb certain rays. Some absorb parts only, and reflect others, which combine together in a colour mixture, and thus give us the impression of colour. Substances, either in a solution or a powder, that absorb certain rays in a high degree are called pigments or dyes. To distinguish them it is necessary to keep in mind that a colour ray emits light, whilst a dyestuff only reflects borrowed rays.

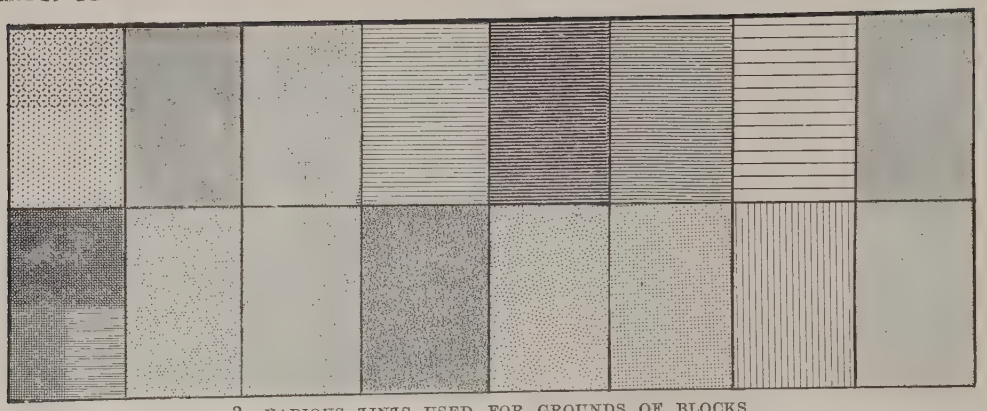
The Principles of the Process. For commercial purposes it is essential that a colour reproduction should be made with as few printings as possible to avoid expense; and it has been found that by mixing three pigments nearly all colours can be reproduced. These printing inks must be very pure and also fairly permanent if exposed to light. It will suffice here to say that the inks adopted are a yellow, red, and blue, which are a compromise between the various conditions



2. WHIRLER AND STOVE

The next thing is to produce negatives to correspond with these inks. They must show no action of light in those parts where the colour of the original corresponds with the ink, and the shades arrived at by blending this colour with the other two primary colours must be represented by gradations in the negative governed by this first colour. We must, therefore, exclude light rays of the particular colour which must be transparent in the negative, and only let those rays act on the plate which are absent in the reflected light of the pigment. Thus, for the red negative the plate must be sensitive to green, and equally for the yellow and blue negatives the plates must be sensitive to their respective complementary rays. To exclude light not wanted we have to employ so-called light filters. These consist of tanks from $\frac{3}{16}$ in. to $\frac{3}{8}$ in. wide, which are filled with aniline dyes in solution. The correctness of these dyes is tested with the spectrum. They have to correspond with the light-sensitive qualities of the plates used.

Dry and Emulsion Negatives. The negatives can be made with dry plates or emulsion.



3. VARIOUS TINTS USED FOR GROUNDS OF BLOCKS

For the former process there are various brands of plates on the market specially prepared for the purpose. For the emulsion process, any maker's emulsion, with the sensitisers sold with it, may be used. It may be added here that though the latter gives much better results, it requires great cleanliness, and cannot be worked in the same room or dark-slide and camera as the collodion process, because any free nitrate of silver has the effect of upsetting the emulsion.

The first negative to be made is the one for the yellow print. Any ordinary dry plate will do for this, as it is not sensitive to yellow, while the lack of red sensitiveness is partly compensated by the ultra-violet sensitive qualities of the plate. For this reason no filter is necessary to exclude yellow rays, the filter being merely filled with ordinary water to ensure register.

A set of dry filters can be procured at any house supplying materials for photo-engraving; but liquid filters are preferable, as they can be regulated very easily if they are not quite true. The best position for them is directly behind the lens. As they deflect light it is best to focus the original after they have been inserted. Plain emulsion, with a standard glycin developer (1½ minutes' development), or ordinary collodion, can also be used for the yellow plate.

The emulsion process corresponds with the wet-plate process in every detail, except that the silver bath is left out, the plate being sensitive to light without it. The coating has to be done in the dark, where the emulsion itself must also be kept. With one maker's emulsion, the method of working is as follows.

The Negatives for the Red Printing. For the second negative, for red printing, a plate is coated with emulsion, as before, but afterwards sensitised with sensitiser "A" (diluted 1 : 10), by floating it over the plate twice; or it can be mixed with the emulsion (1 : 10). For this purpose it is gradually added in small quantities, and shaken vigorously after each addition. Sensitised emulsion must be kept cool, and well shaken before coating. It must, however, be used up quickly, as it will not keep long, and increases in speed as it gets older. As the plate is very sensitive to light, only dark-red light may be used in the dark-room. Before developing, the plate must be well washed under the tap. The filter used is picric acid, about 1 : 1,000, or a corresponding dry filter. For gelatin plates, either orthochromatic or panchromatic plates can be used. Acid green and bichromate of potash solution serve as filter, or a dry filter can be used.

The Negative for the Blue. For the third negative, for blue printing, emulsion is used, mixed with "C" sensitiser in proportion 1 : 40. This is best worked in complete darkness, or with very dark green light. The plate must be washed before exposure. This emulsion will keep in the sensitised state. A mixture of 6 parts Biebrich's scarlet (1 : 1,000) and 10 parts aurantia (1 : 1,000), serves as filter. The same filter will do for red-sensitive or panchromatic dry plates. It is possible to get plates highly sensitive to colour by taking ordinary dry plates, and sensitising them with eosin, silver cyanine, etc.; but the beginner will have sufficient difficulties with ordinary plates or with emulsion without experimenting any further.

Another point which has to be taken into consideration is that if the angle of the half-tone screen is the same in each negative, a very peculiar effect will be given to the finished block, for the three grains will form what is called a Scotch plaid pattern. This difficulty is overcome by using two screens—one ruled at 45°, the other at 105°. For the third plate, the second screen is reversed, giving the angle of 30°. As the cost of screens is considerable, a circular screen has been constructed, which can be turned to any angle required, and thus the expense of a second screen is obviated.

The ratio of the exposure for the three plates is about 1 : 2 : 8, but varies considerably according to the original. The etching, etc., is exactly as in ordinary half-tone process, but, of course, after the first etch, a rough proof in three colours has to be made, to judge whether, and how much, further etching is necessary. With emulsion it is necessary to flash white card for the dark parts, as in half-tone process. This is not done with dry plates.

Collotype Reproduction. This is a purely photographic process, based on the fact that bichromated gelatin not only becomes insoluble when exposed to light, but also retains greasy ink which it otherwise repels. The grain necessary for the gradations of the tones is caused by the reticulation of the film itself.

In the first place a negative is procured either by dry plate or collodion process. If not taken through a prism or from a mirror, it must be reversed. This is very simple with collodion. The film is cut round, the negative put in water, and a piece of paper squeegeed on. The film comes off the glass easily, and is transferred to another sheet, and then back to a clean glass. Should the film be

too weak to stand this operation, it is first coated with a solution of Para rubber in benzol; then, after drying, with ordinary fairly thick collodion. Dry plates give more trouble to reverse, as the film does not come off the glass easily, and stretches considerably. To avoid this, the gelatin must be hardened with alum or formic acid. To make it leave the glass, it is soaked in a mixture of hydrofluoric, acetic, and citric acids, to which glycerin has been added. Instead of glass, the film can be reversed on to celluloid sheets, which, besides other advantages, are lighter, and take up less room,

Preparing the Collotype Negative. The negative is then marked off with strips of very thin tinfoil about an inch wide. This is best done on a retouching desk, where the picture is carefully squared up with pencil on the film side, and the tinfoil stuck on. The latter must be the very thinnest to ensure contact when printing. That the edges must be absolutely square and sharp is obvious. The negative itself must be full of detail and very soft.

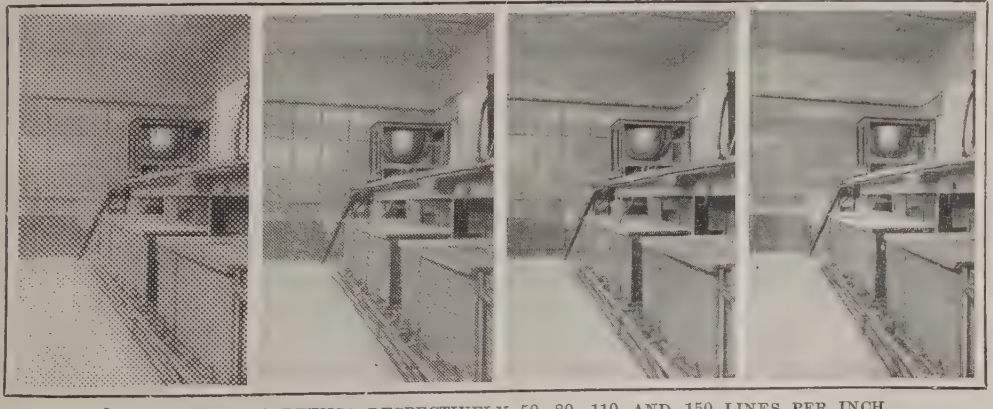
The next thing is to get a suitable support for the gelatin, from which the negative is to be printed on the machine. For this purpose, either glass or metal plates can be used. If glass is taken, one side of it must be carefully grained to give the film sufficient grip. This is done by putting emery paste between two glasses and moving them about gently till an even grain is arrived at. It should be neither too fine nor too coarse. The plate itself must be about ¼ in. thick, to avoid breakages, and the edges should be bevelled, as they might otherwise cut the inking rollers in the machine. Copper, zinc, or aluminium can also be used. Zinc is cleaned with emery powder and a brush, and then passed in a weak nitric acid and alum bath. (Formula: 60 minims nitric acid, 1 quart water, and 1 oz. alum.) Copper is ground like a glass plate, and aluminium is treated with weak sulphuric acid (1 : 31) or with a strong potash bath.

Glass, before being coated, has to have a substratum of albumen and potassium silicate. (Formula: 7½ parts albumen, 3¼ parts of potassium silicate, and 9 parts of water.) Instead of the albumen, stale beer may be used. The mixture is well beaten up and filtered, and after dusting the plate, is poured on, drained off, and dried. The plate is then washed to remove superfluous silicate, and dried again. Before coating, the plates are evenly heated to about 120°, great care being taken to prevent them from sweating. This is best done in a drying oven on a levelling tripod, where the plates are also dried after coating.

Coating the Plate. The solution consists of gelatin or isinglass, some bichromate salt, ammonia, chromic alum and water. The gelatin should be fairly hard, as this gives the plate a longer life on the machine, though it gives more trouble in etching. Both bichromate of potash and ammonia are used. The proportion of the two is ruled by the fact that the former is slower than the latter. A plate coated with the two gives more detail in the dark parts, and more definition than if one salt only is used. The proportion of the bichromate to the gelatin is defined by the salts crystallising out, if in excess. The proportion of gelatin to water is about 1:10, and a little chromic alum is added to avoid excessive relief. The gelatin is first swelled in cold water, and the salts used are dissolved in another vessel. The gelatin is then heated, but not more than from 120° F. to 140° F., and the salts are gradually poured in and stirred. The solution is then filtered through chamois leather, if possible by a filter pump. The solution must be kept warm during the filtering and coating. The plate is fixed on a tripod and warmed, as previously described, and the liquid poured on. It may be guided a little with a clean glass rod to spread it evenly over the plate, and the utmost precaution must be taken that no bubbles or particles of dust remain.

Drying and Exposing. After coating, the plate is dried at about 120°. This takes about two hours. During and after this time it must be kept in the dark, as, once exposed, the action of the light continues and spoils the plate. When dry, the plate should be perfectly even and matt. If glossy, it shows that the gelatin was too cold. Any vibration or cold draught during drying will be shown by wavy or streaky marks. The plate is exposed to light in frames, exactly as in half-tone process, and if several negatives have been stripped on to one plate, they can all be printed at the same time. All waste space between pictures has, of course, to be masked with tinfoil. For exposure, it is best to use an actinometer. If glass plates are used, an additional short exposure to the plate from the back is advisable, as this gives the film more hold on the glass and prevents excessive relief of the picture.

The plate is then washed in cold water, till all unexposed bichromate is removed. This takes about two hours. The subsequent drying also takes a few hours, but at least a day should be allowed to pass before the plate is put on the machine, to give the gelatin time to harden.



4. HALF-TONE SCREENS: RESPECTIVELY 50, 80, 110, AND 150 LINES PER INCH

The So-called "Etch." The plate is then put into a bath of water, glycerin, and salt, ammonia being sometimes used instead of the latter. The object is to make the plate absorb moisture. This is called an "etch" (though it is nothing of the kind). It is done to enable those parts which have been exposed least, and which, therefore, absorb more water, to retain the smallest quantity of fatty ink in the printing, whilst the fully exposed parts hardly absorb any water, and therefore retain nearly all the ink. After about half-an-hour, the plate is taken out and wiped with a sponge and dabbed with a clean rag to dry it. The ink used must be very stiff, only thinned down with a little varnish. It is rolled up very carefully with a nap roller till the plate, which will not take any ink at first, looks black all over. It is then rolled with a composition roller, which cleans it up, and is now put into the press. An albion, lithographic, or even a letter-copying press will do. It is best to put a few sheets of paper under the plate to prevent breaking, and to back the proof sheet with blotting paper. If on the proof the shadows are filled up, and the high lights are dirty, the plate is cleaned with turpentine, and re-etched. This is repeated several times until a satisfactory result is obtained.

Skies or dirty margins are cleaned up by etching the plate with a weak cyanide of potash, or a strong hypo solution, on a brush. If the plate is wanting in contrast, an etch is given without cleaning the ink off. For a short run, the plate margins can be masked with oiled paper instead of being etched with cyanide. When a proof shows a satisfactory result, the plate is ready to be put on the machine.

The Art of Photogravure. Photogravure is an intaglio process—that is to say, the surface of the plate does not represent the picture, as in all the other processes, but when the plate is inked in, the surface itself is wiped clean, and the picture is produced by the paper being pressed into the crevices to pick up the ink. The process of producing the plate is not complicated, but requires great skill in the final stages, and a good deal of artistic sense and judgment.

In the first place an ordinary negative is made from the original, and from this a transparency either on a dry plate by contact (and if another size is wanted, in the camera), or on a pigment paper. For the latter purpose, a so-called autogravure tissue is procured. Of the two kinds, it is better to procure the one not sensitive to light, as the other does not keep. Before use, it is sensitised in a bath of bichromate of potash and water with a little ammonia added, for about three minutes. A piece of plate glass is then carefully cleaned, rubbed over with French chalk, coated with plain collodion, and the tissue squeegeed on to it. This must be dried in the dark, for, when tissue is once exposed to light, the process of making the gelatin insoluble continues. The negative is then safe-edged—that is, all the edges of the picture are covered with strips of black paper or black varnish.

Another glass plate is then cleaned, coated with bichromated gelatin, and, after drying, exposed to light, to make the gelatin insoluble in hot water. This is to serve as support to the tissue during and after development. The tissue is then exposed to light behind the negative, and as this carbon process cannot be watched, an actinometer must be used with a piece of P.O.P. First the speed of the tissue (which varies according to the make) will have to be tested by comparing it with silver paper which is exposed simultaneously.

After exposure, the paper is put into cold water till it loses all tendency to curl. It is then squeegeed on to the gelatinised plate, and after standing for a few minutes, is developed in water at about 120° F. The backing paper will then come off easily. The water is now renewed, and the picture can be dried as soon as it has been well developed and all soluble matter removed. Under or over-exposed plates will be useless, as all the detail must be clearly defined both in the high lights and shadows.

The copper plate is now dusted in with finely powdered bitumen. This is done in a so-called "dusting box" containing a fan, which violently whirls up the dust. The copper plate, carefully cleaned with whiting and ammonia, is introduced in the centre on a large board, and the dust is allowed to settle. The longer the plate is left in the box, the finer and closer the grain will be. The time is from five to ten minutes. The plate is now heated, and the bitumen melted on. If the graining is not sufficient, the plate can be put back into the box again, and the process repeated.

Finishing and Etching the Plate. For the next stage, a special autogravure carbon tissue is prepared as the one before, except that the glass plate must not be collodionised. It is exposed behind the transparency, the latter having been safe-edged previously. After exposure, it is taken out, immersed in water, and rubbed gently with a sponge to let the water soak in evenly. The copper plate is also sponged and the tissue squeegeed on to it, and then weighted, after backing it with blotting paper. It is developed as before and is ready for etching, the margins having previously been dried and varnished.

The solution for etching consists of perchloride of iron in water, the perchloride having been neutralised with ferric oxide while hot. There should be five baths, varying in strength from 45° to 32° Beaumé. These baths can be used over and over again, as they improve with use. They will have to be tested occasionally for strength. The plate is first put into the weakest solution (45° Beaumé), where it remains till the copper under the shadows discolours (about one minute). The next two solutions, which attack the half-tones, take about one and a half minutes, while the final baths take from two to three minutes respectively. The plate should be etched one minute after the highest lights have been attacked. Finally the plate is cleaned with carbonate of soda, the film rubbed off, and the margins cleaned with benzol, and brightened up with weak caustic potash and very weak sulphuric acid. When the plate is quite finished, defects can be remedied by rouletting and burnishing. After this, the plate is steel-faced and is ready for proving.

Classes. Classes in the above processes are held at the Polytechnic, Regent Street, and the Bolt Court School of Engraving, Bolt Court, Fleet Street, London, as well as in similar institutes all over the country.

P. G. KONODY

Private and Political Secretaries. Parliamentary Agents. Lecturers. Institution Officials.

THE WORK OF THE SECRETARY

Secretaries. No particular technical training can be prescribed for the secretarial life. There is no one branch of knowledge in which the private secretary must excel, yet he should be in some sense acquainted with them all. The berth is pre-eminently one for a man of good general education and some knowledge of the world. It is one into which some men drift almost by accident, to remain there all their lives; others use it as a stepping-stone towards a more satisfactory position.

The Amanuensis. Broadly speaking, there are two classes of secretaries. The first is essentially a letter-writer, a very necessary adjunct to every wealthy man much occupied with affairs; the second—the political secretary—is an incidental luxury in literary and political life. The duties of a secretary of the first class are in many cases heavy, and the pay, except for rare and fortunate individuals, low. Such a secretary is, in fact, a clerk of more or less skill and responsibility; he has a clerk's duties, a clerk's position, and rather less prospect of promotion than most clerks enjoy.

Still, if a man can be satisfied, for a time at least, with an income of £100 to £150 a year, he may do worse than become a clerical private secretary to a person of influence and position. There is always a chance of impressing his chief with his ability and character, and so securing transfer to a more responsible post.

Qualifications and Position. The qualifications required by a secretary of this class are substantially those of a clerk in a City office. He must have some knowledge of typewriting and shorthand, a presentable appearance, and sufficient acquaintance with the English language to be able to write a good letter. Above all, he must be able to produce evidence of high character, and must show himself possessed of common sense and great discretion. His employer wishes to be relieved of responsibility in the smaller matters of everyday life; and a secretary who can be trusted to look after things intelligently on his own account becomes indispensable to a busy man, and can make his own terms.

On the other hand, a secretary of this class must be at the beck and call of his master. Not infrequently he lives in the house, and is hardly free from duties morning, noon, or night; no Factory Act applies to his employment, and no code defines his social position. Altogether it is a strenuous life, and a poorly paid one.

The Political Secretary. But the position of a secretary of the second class is very different, and far more satisfactory. His mission is mainly to serve as a well-informed companion and friend of his principal, who is often a business man unfamiliar with political and social interests. His employer's lack of knowledge is the political secretary's opportunity.

The salary of such a secretary is from £200 to £500 a year, and his social position is not so far off his chief's. Many Parliamentary private secretaries are less the servants of their immediate employers than apprentices to the game of politics, just as the editor's private secretary is an apprentice to journalism.

Posts of this class, however, are not so easily found as the ones before described. A luxury is expected to be a highly finished article. Generally, a Parliamentary secretary is an Oxford or Cambridge man, though some of the most successful ones have not been through the university. But, whatever his training, the qualifications of such a secretary are varied and peculiar.

Lord Brougham said once that the King knows as much law as his Chancellor, but the Chancellor knows where to find it. Even so the secretary—facts and figures, books and blotting-paper, he must know where to lay his finger on them all. Beyond this, unless he writes letters, which many do not, he holds something of a sinecure, and that not ill paid.

To the man contemplating a political career, no training could be more valuable than a year or two as private secretary to some prominent M.P. He meets many important people; he appears occasionally on his chief's platform, and learns to face an audience without quailing. When duties press heavily on the member, the secretary may be charged to make notes for a speech in the House, and so himself lend a hand with the helm of the vessel of State.

And the field is an open one. Some posts, of course, go through influence, but the central party agent can always find a berth for a man who impresses him favourably.

The Woman Secretary. There are many well-paid openings for women in the secretarial world. Authors, editors, and social and philanthropic workers, as well as men of business, find that a trained and tactful confidential secretary can lighten their shoulders of a great burden of work and worry; and many who would shrink from allowing a man to have access to their private papers and personal affairs have no hesitation in confiding these to the charge of a woman of the right type. For such duties a salary of £3 to £6 a week is not considered excessive.

The qualities needed for work of this kind include, in addition to those of the trained

typewriter-clerk, the wider outlook and surer judgment of a well-educated gentlewoman. The woman secretary requires especially the solidly based self-confidence that enables her to handle details without troubling her principal for directions. There are several secretarial bureaus that provide a useful course of training, extending over six or twelve months, at a cost of £20 to £50. But the woman who succeeds as a secretary does so primarily in virtue of personal qualities and force of character.

Political Agents. The same comment may be made on the profession of Parliamentary agent. Each of the two great political parties has an institution for training its agents in connection with its central association, and issues certificates to those who are qualified. But the really successful agent is he whose full energies and abilities can be thrown into the great game of politics because he finds the game absorbing for its own sake. To such a man the work offers a congenial career and the satisfaction of doing yeoman service to his party.

It has even been said that the personality of the agent is more important in a constituency than that of the candidate.

The Parliamentary agent usually begins as an assistant or sub-agent, thus gaining useful knowledge of election law and practice, which should be supplemented by the study of modern political history. It is a great advantage if he can speak readily and pointedly from the platform, but the first essentials are boundless energy, organising ability, and tact.

The Agent's Duties. Apart from election times, the political agent's chief concern is to "nurse" and safeguard his party's interests in the constituency. He must study local industrial conditions and the political questions most affecting the electorate. Much time and trouble must be devoted each year to the revision of the register of voters for the division, to ensure that all electors of the right political complexion appear upon it, and that all claims for registration issuing from the opposite camp are scrutinised for possible flaws. This involves some strenuous fighting before the Revising Barrister.

When an election is pending, the candidate appoints an election agent, who is usually the local Parliamentary officer. Then follows for the agent a whirl of multifarious activities, increasing in intensity until the day of the election itself. An election agent needs a strong constitution as well as political ardour to carry him through the strain of such a time.

Considering the demands made by this calling, its rewards are not high. Salaries range between £120 and £400 or £500 a year, £250 being about an average figure.

Lecturers. Apart from posts at the universities, which were discussed on page 5352, the calling of the lecturer is usually entered by one of two doorways. The first is open to almost anyone who attains distinction in some special and interesting department of knowledge, even though he or she has few natural gifts for lecturing, and had never contemplated it as a career. Whatever the subject—whether wireless telephony or mediæval music, the private life of the Kaiser or of the ant, Egyptian symbolism or germ-cells—the acknowledged expert is likely to be approached by some wide-awake lecture agency with a tempting offer of guaranteed fees. The European War, for instance, is now providing and will continue to furnish subjects for the lectures of a whole generation of experts, both military and historical.

The second class of lecturer belongs to the order of popular entertainers. Like the actor or singer, he begins without a ready-made reputation, and must win the suffrages of his public by his personal qualities and gifts. Of these the foremost essentials are a good delivery and pleasing voice, ready speech, a sense of humour, and that indefinable power of holding the attention of an audience which many men enjoy who are faulty orators. A degree is useful also as a proof of education and ability.

For the unknown man or woman, lecturing is usually an uphill calling, during the early years at least, and its remuneration is not comparable with that of the stage or even the concert-room. At first, engagements are few, even at a guinea an evening. As the lecturer's reputation grows, so do his fees, but many men of standing in the profession are glad to receive five guineas for a lecture. The surest way of earning a steady income is an engagement with a good lecture agency, which arranges full winter courses of lectures for its clients at an agreed fee. With a few outstanding exceptions, £10 10s. an evening is a high figure for the lecturer of this class. And late hours, night travel, and the nervous strain attending all public speaking make the life a trying one.

Institution Officials. The many posts for workers of either sex in charitable institutions, social missions, and learned and other societies are so various in their requirements as almost to defy any method of grouping. Most of them require some special knowledge of the conditions affecting their own particular activities. Thus, in charitable and social work, some experience of the wants and ways of the poor is generally essential, as well as the ordinary qualifications of a clerk or secretary.

The leading officials of a literary or learned society have usually served their informal apprenticeship in its office, and their intimate knowledge of the society's workings enable them to command salaries of from £300 to £800 a year. Charitable institutions are seldom able to pay adequate salaries, but the opportunities they offer of useful service attract to them many able men and women. The Charity Organisation Society employs a large staff of gentlewomen, who usually give their services for the first three months. They then receive £80 a year as assistants, and, if suitable, become local secretaries at £100 or £150. Matrons in industrial homes can have had no more useful training than that of probationer in a hospital, added to some knowledge of cookery or housework. Their salary ranges between £30 and £70, with board and residence.

Opticians. Painters and Decorators and Plumbers.
Photographers and Photographic Dealers. Saddlers.

ENCYCLOPAEDIA OF SHOPS—9

OPTICIANS

Qualifications. The man who intends handling an optician's business needs a certain amount of scientific and technical education. If he has had the advantage of being apprenticed to an optician, so much the better, but in any case he should take a course of lessons in technical and practical optics, such as those conducted by the Northampton Institute, Clerkenwell. Day and evening classes are arranged at moderate fees. Optical classes are also held at various centres in the provinces, and in London by private instructors.

Examinations are held by the British Optical Association and the Spectacle Makers' Company, and the diploma of one or both of these bodies should be secured. Full particulars as to the fees and subjects of the examinations may be obtained from the societies in question; and it is safe to say that the opticians who are able to pass both the elementary and advanced examinations have an excellent working knowledge of optics, which gives them considerable qualifications for their difficult and highly technical business.

The optician cannot, of course, expect to go into cases of disease affecting the eyes, nor should he attempt to do what is essentially the work of the oculist. But there is no reason why he should not become skilled in testing the eyes for the more common defects—such as, for instance, short sight and astigmatism.

Capital for an Optician. To start an optician's business independently of any other trade requires a capital of about £250, but, of course, if the business is to be only a department of a jeweller's or chemist's shop, then much less will do. Of the capital named, £20 may be spent in window fittings and outside signs, £40 in shop fittings, £100 in stock, £10 in testing-room fittings, £15 in testing appliances, £5 in workroom appliances, £10 in advertising, and £50 may be left for working capital.

Shop and Window Display. For an outside sign a large pair of gilt spectacle-frames are excellent, because, while being dignified, they tell the story at a glance. Such a sign will cost about £2; and enamelled spectacles may be affixed to the windows, these costing from 5s. to 10s. a pair. Fancy names for opticians' shops, like the Ophthalmic Institute, Sight-testing Parlour, Refraction Rooms, and so on, should be avoided, as they have about them a smack of quackery which makes the better class of customer suspicious.

For the windows the framed diplomas won by examination make excellent advertising; and models and coloured charts of the human eye, busts with faces wearing spectacles and eyeglasses, lumps of Brazilian crystal, and sight-testing designs all make popular attractions. Spectacles and eyeglasses, frameless and in all kinds of frames, should be prominently displayed on coloured velvet; and if a set showing the various stages of a pair of spectacles, from rough crystal to the finished article, can be obtained for window display, so much the better. Velvet stands for the display of folders and spectacles are also made, and should be obtained.

Shop Fittings and Stock. In the shop a number of dignified charts may be displayed, but care should be taken that these do not give a suggestion of cheapness or quackery. The counter should be covered by a glass case containing spectacles, lying on a velvet ground. A stereoscope standing on the counter, with a view ready in position, is an attraction.

The stock will include spectacles in gold, gold-filled, and steel frames, and also frameless; eyeglasses in the same varieties, astigmatic clips, blue and tinted glasses, monocles, rimless and framed, motor goggles, lorgnettes in tortoiseshell and celluloid, shooting-spectacles, pocket lenses, reading-glasses, eyeglass cords and chains, spectacle and eyeglass cases, including châtelaine cases, artificial eyes, eyeshades, eye-baths, lens cleaners, and one or two microscopes.

Sight-testing Room. For sight-testing a room 10 or 12 ft. by 15 or 16 ft. is necessary, and the walls should be distempered a dull leaden colour. No pictures should be on the walls to distract the customer's attention, but test charts should be hung at one end, and there should be a comfortable chair at the other end, 10 ft. from the chart, and raised on a platform. This raising of the chair is useful for seating the customer so that he may have his eyes level with the charts, and it also gives an air of importance to the testing-room.

Light is an important item in the testing-room. If the natural light is not very good it is necessary to have a good artificial light, shaded and so arranged that the illumination of the chart is even. At least £10 should be expended on the case of trial lenses, everything, of course, depending upon their accuracy. The case should stand on a table by the side of the testing-chair. Various sizes of reading type must also be available, together with a trial frame, optician's rules, face measures, and prescription book in which to record details of each customer's needs. A hand-mirror and a wall-mirror should not be omitted from the equipment, for the use of ladies whose hair may get disarranged.

Method of Testing. The method of testing is as follows: the customer is asked to be seated, and the optician then takes up his place behind the chair. He adjusts the trial frame on the customer's face, and while each eye is being tested separately an opaque disc is inserted to blind the other eye. The left eye is first covered, and the customer is asked to read what he can on the test chart with his right eye. If he cannot read all that he should, a + 0·50 lens is put in the trial frame. If this lens improves the vision the case is one of hyperopia, and the optician continues to substitute stronger lenses until one is found that gives perfect sight. If, however, the customer could not see so well when the first lens was used, then it is changed for a − 0·50 lens. If this assists, the case is one of myopia, and the range of these lenses is gone through till perfect vision results. The left eye is afterwards tested independently in the same way.

Where, however, the customer is unable to see plainly all the radiating lines of an astigmatic chart,

the ordinary spherical lenses must be replaced or reinforced by cylindrical lenses, which are rotated until all meridians of the chart are clearly seen. To go into all the tests for different defects is impossible here, but they are described in the standard text-books on the subject.

The Optician's Workshop. The optician's workshop will need an equipment including a bench, a lathe, a lens surface grinder, lens testers, optician's pliers, screw-drivers, soldering apparatus, tweezers, screw extractors, lens drills, and a grind-stone if much mechanical work is to be done, but it will be better for the beginner to get the wholesale opticians to undertake his repairs.

Profits. The optician's business should be a cash one, and on many of the things which he sells his profits should be 25 per cent. Much depends upon the class of customer that he gets, as much better prices can be obtained for the same goods in some districts than in others. Prescription work—the carrying out of the prescriptions of oculists—should be cultivated, as not only does it bring customers for the spectacles, but if they are satisfied they are likely to come to the same shop for all their repairs and renewals.

Scientific Instruments. Another side-line that goes well with an optician's business, and also with a jeweller's, is the supply of scientific instruments. Of course, in few districts is there any very large demand, but, as the profits are roughly from 25 to 33⅓ per cent., the trade is worth catering for. In the neighbourhood of technical institutes, science schools, and the like, the demand is greatest, especially in provincial cities. Scientific instruments and apparatus should include optical instruments and lenses, radiographic, meteorological, and mathematical apparatus.

Chemical apparatus, electrical apparatus, hydrometers, alcohol-meters, and all the other instruments of this class, theodolites, compasses, sextants, slide rules, measuring instruments, and many others, are all in a certain demand wherever students of engineering and chemistry congregate.

PAINTERS AND DECORATORS

Contrary to the usual run of shopkeeping, capital in the painter's and decorator's business is not wanted *chiefly* for goods in stock for sale, nor for material to be used on the work, but will be required to pay the wages of operatives while work is in progress. Wages in the painting trade average from 65 per cent. to 75 per cent. off the net cost of the work, which may not be returned for some months.

It has been said that a small business could be started on a capital of £60. That sum named would suffice only for the smallest possible business with barely such equipment as would serve the requirements of two or three workmen at most, without margin for extension of credit and ordinary risk on occasion, and without stocking any materials. For a concern capable of dealing independently with the average requirements of a moderate class business in the present day, it will be readily admitted that a sum of at least four times that named above, or, say, from £250 to £300, should be available.

Credit. A partial set-off against the credit to be given is that when a business is well established the manufacturers and merchants who supply the trade offer similar credit for materials used. It follows, therefore, that with moderate good fortune a business should adequately finance itself after, say, the first year, with reasonable progression.

A considerable part of preliminary outlay will be for painters' brushes, tools, and scaffolding, such as step-ladders, planks, long and short stave-ladders (for outside painters' work), handcarts, etc., none of which will be directly chargeable to any client's account, and can be recovered only by the charge of a proper percentage for indispensable wear and tear.

It must also be remembered that the master is responsible, under the Employers' Liability Act, for the safe condition of all scaffolding, and must be prepared to compensate any workman who may receive injury through defect therein. This is usually covered by insuring, and the premium paid must be charged to the account for maintenance of scaffolding.

Preliminary expenditure on materials may be limited to the needs of the workshop, as the modern custom of keeping little or no stock of paperhangings or other decorative fabrics, now mainly sold from the attractive pattern-books supplied by the merchants, leaves the investor free to apply that capital in other directions.

Showroom. A minor business such as that quoted at £60 may possibly be conducted without a showroom, but not so the moderately good-class business, with a progressive future.

The higher-class wall-papers are made up in large "stand" books that may be displayed in an upright position on the floor of the showroom. For convenience of carrying to clients' own addresses for selection to be made, some merchants supply also a smaller-sized pattern-book of the same contents, and this will rest on the showroom table among other similar-sized books containing patterns of the various grades of lower-class goods. It is the general custom for the merchants to mark on the back of each pattern the full retail price, from which a substantial discount of 33⅓ per cent. is allowed to the trade, no part of which should, in justice to the responsibilities of the business, be sacrificed to the client.

Both merchants and manufacturers supply the trade in this way, but the merchants will be found the most convenient to the beginner, as their selections are made annually from the various manufacturers' productions and arranged in harmonious "sets," thereby presenting great variety. Every pattern inserted in the books is kept in stock during the season—extending generally from September of one year to September of the following year—and sometimes a successful pattern may be carried forward from one season to another.

Showroom Fittings. The walls and ceiling of the showroom should be decorated with different materials in a variety of styles to show, say, three methods of treating a drawing-room, the same number of dining-room schemes, and a smaller number of schemes for other departments as space may allow, separating these into sections by the use of mouldings, that may be shown as samples of panel, picture, dado, or other mouldings used in similar positions occasionally by the decorator in the conduct of his business. These sectional examples should each be a display of good taste and careful workmanship, to inspire confidence in the customer as well as suggesting suitable modifications and colour harmonies, blending or contrasting, brilliant, medium, or subdued in tones, light and airy or deep and rich, as occasion may require.

Examples of painted woodwork should also be found in some variety in every showroom. These may take the form of doors, panelled on both sides, and hung upon posts between the sections of wall decoration so as to swing either way and display

suitable varieties of painting in harmony with the wall schemes. One side of a door may be finished in a variety of grained woods, such as oak, mahogany, walnut, pitch-pine, maple, etc., as the painted imitation of these is occasionally called for.

Fitments, such as a "cosy corner," where clients may sit while selecting their wall-papers, and an arched screen between showroom and office, from which artistic drapery may hang, and in which ornamental stained glass or leaded lights may be effectively displayed, should find room where possible, because it frequently comes within the decorator's province to recommend and supply such fitments to complete the decorations of a house. These are usually white enamelled with good effect. The screen need not be higher than seven or eight feet, allowing ventilation and light over the top. In front of this screen there may be brass rods, fixed several inches from the wood, over which sample rolls of wall-papers may be hung for display.

A long, low table with shelves underneath, for the display of smaller pattern-books, colour studies, etc., a few comfortable chairs, and the indispensable good carpet or linoleum on the floor, practically complete the up-to-date showroom.

Shop Window. It is generally to the advantage of a good class decorator's business to make but little display of goods in the window. A white enamelled screen dividing the window from the showroom may be made to support a simple pleated curtain of unobtrusive art shade as a background, and a linoleum of subdued contrasting colour on the stage flooring, with one stand pattern-book opened at a pleasing decorative scheme, showing perhaps a deep attractive frieze with harmonious filling, and maybe a yard or so of rich brocaded silk draped over one end of this, will, as a rule, impress the right people in the right direction for good-class business far more than a heterogeneous assortment of many samples. A pretty and always attractive addition to the window display is an ornamentally designed easel, upon which rests a picture or a small-scale drawing of an interior, drawing or dining room, billiard-room, hall, or other example of decorated work in colours, which may be obtained from the trade journals or from special artists if the decorator does not produce such drawings himself.

Wall-paper Stock. Where business prospects reasonably demand the keeping of a stock of wall-papers, this stock should generally be confined to the more ordinary kinds and lower qualities, in the sale of which there is less fastidiousness to contend with than in the higher-priced goods.

The manufacturers and merchants quote specially low prices for "stock" orders, in "bales" of stated quantities, as a minimum total. This compensates the decorator for special risks, and enables him, when his stock patterns are selected from the pattern-books, to net an extra profit, while losses upon remnants costing, say, from 2½d. to 6d. per roll of a dozen yards—of which the average room requires from seven to ten pieces—will never amount to a very large sum.

A moderate outlay on these goods, say, £30 or thereabouts, would be adequate for a start, and might be made to embrace 70 or 80 varieties in lots of 25 or 30 each, with a total of about 2000 rolls in all. These will be renewable as required during the current season, and renewals should always be compared for exactness of shades before placing into stock, and any variation should be kept apart from previous stock.

Enclosed shelves or "racks" will be required for convenient storage of these goods The carpenter's work for construction of such racks as usually made for the purpose may be set down at about 50s. per 1000 rolls it is intended to place in stock. Each division of square shelving should hold about 30 or 50 pieces for economical manipulation.

Sale-shop. In connection with a good-class business in large towns there is very little cash trade usually carried on over the counter in the form of sales of materials only, though when a stock of paperhangings is laid in it becomes a paying department in a district where there is a considerable section of the public accustomed to buy these goods, arranging elsewhere for fixing. This is especially the case in country market towns.

Ready-mixed Paints. A profitable addition to this department will be a stock of ready-mixed paints in lever-top tins of saleable sizes, such as 1 lb., 2 lb., 4 lb., and 7 lb. These are obtainable in various qualities from most paint manufacturers. A good quality sold at a fair price will be the most profitable in the long run, as the commoner qualities have poor covering power, and are apt to become viscid by remaining in stock.

Paints ground to a stiff paste in linseed oil, such as white lead, ochres, umbers, reds, blues, greens, etc., may be likewise saleable, and could be kept underneath the sales counter in small kegs, covered with a little water (renewed daily), and a small wooden spatula kept in each would serve to supply the required quantities. A horizontal scale or spring balance for weighing these will be required.

Oddments of Stock. Painters' oils and varnishes will form other items of probable sales in this department. These are sold by measure, usually by the gallon, half-gallon, quart, or pint. In varnishes the sales will generally be confined to three or four varieties, such as pale and hard oak varnishes, black japan, stains, etc. Makers supply these made up in small-sized sealed tins, for convenience of sale. Painters' oils and spirits are not put up in this form, and must be sold from bulk.

Painters' brushes, tools, and sundries are likewise saleable stock, and may generally be of cheaper qualities than used by the trade workmen, as those who buy for a mere temporary purpose can seldom be induced to pay the price of the quality necessary to the expert.

Glass-cutting may also be a profitable branch of the sales department, but would be best conducted in the workshop

Profits. It will not be found profitable to conduct this business on a margin of less than 33⅓ per cent. gross—that is, one-third of the selling price—to represent profit, which is the trade discount officially arranged by the merchants and manufacturers in pricing their pattern-books.

Workshop and Stores. The store and paint-shop may be together or separate; the workshop is better separate where space permits. They are usually situated in back premises, and should be convenient for delivery and despatch of heavy loads by horse vans, with, if possible, a good yard for storage of long ladders, planks, scaffolding, hand-carts, empty paint casks, etc., and a "lime-pit" for slaked "putty lime" (used in repairing plaster work prior to painting and paperhanging, and for lime washing); covered sheds are usually provided for these items. In the stores, shelving, in several tiers above a bench, fitted around the walls may contain all the dry colours—in tins or strong paper bags, as delivered, the more expensive coloured pigments ground in oil and turpentine, such as lakes, siennas, Vandyke

brown, drop black, and decorators' large tube-colours, also the stock of varnishes, enamels, and the like, while from hooks in the ceiling should be hung the reserve stock of empty paint-kettles.

Storing Stiff Paints. The heavy paints for ordinary use, ground to a paste with linseed oil, such as white lead, ochre, umber, reds, blacks, driers, etc., may be stored under the benches, where they are easily obtained as required by opening the kegs, keeping a little water on the top of the paste to prevent it drying, and with a trowel or strong wooden spatula in each. A good spring balance should find a place on the bench, so that every article taken out may be weighed and booked, together with the name of the client or job for which it is taken, the same care being taken to book all returns, with similar particulars, adding the dates in each case. Near the scale on the bench should be a small desk, on which is always to be found the "workshop day-book," specially reserved for the entries just named, from which the general bookkeeping of the business may from time to time be accurately made up. In the centre of the store a square table covered with baize should be reserved for glass-cutting, and in a safe corner racks provided for glass.

The workshop should be fitted with benches with one or two shelves above, and drawers beneath, occupying two sides of the room, preferably with north and west aspects, as it is desirable to avoid direct strong sunlight for paint mixing. Some pigments are of a more or less gritty powder, and occasional grinding of these calls for the provision of a paint-mill (small hand-power cone mill), usually screwed down on to the bench of the workshop, and also of a paint-slab, with a stone "muller" or hand-grinding stone upon it. A good slab is one of thick plate-glass, ground to a very level surface, and set in a bedding of cement or white lead putty, with its frame bevelled off, and screwed down to the bench. A granite cobble-stone cut into halves will make two good mullers or grinding stones.

Oil Storage. In a corner of the workshop or stores a place must be found for three oil-tanks, or a stillage on which the export barrels may be placed when received. The former is the best plan, as there is sometimes leakage and loss from keeping the oils and turpentines in the wooden barrels as supplied by the merchants, due to shrinkage of the wood. Each of these tanks may contain from 50 to 150 gallons of liquid, and is fitted with a tap near the bottom for drawing off the oils as required. One will contain raw linseed oil, another boiled oil, and another turpentine, all of which are indispensable to the mixing of various paints.

In another corner bins are required for the storage of whiting and plaster. These should be in the driest corner, and kept dry by being slightly raised from the ground.

A pickle cask, large enough to hold ten to twenty paint-pots and kettles, should find a place under one of the benches. In this a solution of strong soda or caustic soda should be kept, and dirty paint-pots be placed in it as returned from operative work. They may be removed the following day, and will easily be made fresh and clean by washing in clean water to be ready for further work.

Smudge Pots. Any old paint mixed and returned as surplus from work done should be carefully saved, and emptied into receptacles kept under another bench for the purpose. These receptacles are called *smudge pots*—one is reserved for white, another for pale colours, another for dark colours—and within a reasonable space of time the contents of these smudge pots may be used for ordinary work, or later form a good addition to red lead paint for priming new work.

On the shelves above the paint-benches will be kept small jars of all usual paint ingredients, to be handy for frequent use, also palette knives and cleaning rags, of which there should be ample quantity, to prevent wasteful and objectionable untidiness.

On one of the benches small articles such as notice-boards, door-plates, etc., may be painted and lettered, also any embossing or gilding on glass may be carried out, while the centre of the workshop may be reserved for pieces of furniture under process of painting, large signboards upon easels, for lettering, etc., and the two blank walls not yet dealt with may be boarded and reserved for sketching out plans of wall or ceiling decoration from time to time to facilitate the actual work when operations are begun.

In the drawers under the paint-benches may be kept the decorators' pencils, tube-colours, palettes, etc., also stencil patterns, gilders' materials, and other small items of value, or for occasional use.

In beginning business, so many articles are required that it is a matter of some difficulty to keep within small expenditure. But by first making sure of indispensable articles in minimum quantities, and by adding small quantities of the remaining requirements, any shortage or omissions can be made up as occasion may require.

Stock for Workshop and Stores. On these lines, the following list may be taken as a minimum stock to start a business where work for at least half a dozen men and one apprentice may be anticipated:

PLANT

8 long ladders, assorted sizes, from 10 ft. to 40 ft. length, 12 pair assorted step-ladders, 5 ft., 7 ft., and 9 ft.; 2 pair 9 ft., and 2 pair 11 ft., painters' trestles; 3 doz. scaffold planks (2 in.), assorted, 6 ft. to 15 ft. long; 2 paperhangers' folding tables and trestles; 2 hand-barrows, with steel springs.

WORKSHOP AND STORES FITTINGS

Carpenters' work; paint mill; muller and slab; 2 strong easels; gas or electric fittings; 3 oil-tanks; spring balance, and sundries.

STOCK OF PAINTS, OILS, VARNISHES, BRUSHES, etc.

Turpentine, 1 barrel (3 cwt.); raw linseed oil, 1 barrel (3 cwt.); boiled linseed oil, 1 barrel (3 cwt.); white lead, ground in oil, 5 cwt.; zinc white, ground in oil, 3 cwt.; patent driers, ground in oil, 1 cwt; Oxford ochre, ground in oil, 1 cwt; raw umber, burnt umber, Venetian red, Indian red, Brunswick greens (light, middle, and deep), and vegetable black, all ground in oil, of each, ½ cwt.; Prussian blue, raw sienna, burnt sienna, Vandyke brown, orange chrome, lemon chrome, ground in oil, of each, 7 lb.; drop black, ground in turpentine, 14 lb.

DRY COLOURS.

French ochres, Venetian red, raw umber, burnt umber, lime blue, of each ¼ cwt.; Indian red, lime greens, vermilionette, and ultramarine blue, of each, 7 lb.; vermilion (genuine), 7 lb; lemon chrome, orange chrome, middle chrome, of each, 7 lb.; dry white lead, dry red lead, of each, 14 lb.; 10 cwt. best Paris whiting.

VARNISHES AND ENAMELS

5 gal. (in 1 gal. tins) best copal oak varnish (for outside); 5 gal. (in 1 gal. tins) best copal oak varnish (for inside); 5 gal. (in 1 gal. tins) common oak varnish (hard); 1 gal. (in ½ gal. tins) decorators' carriage varnish; 1 gal. (in ½ gal. tins) extra pale maple varnish; 1 gal. (in ¼ gal. tins) ivory white enamel (slow setting); 1 gal. (in ¼ gal. tins) snow-white enamel (slow setting); 1 gal. (in ¼ gal. tins) black japan; 1 gal. (in ¼ gal. tins) Brunswick black; 1 gal. (in ¼ gal. tins) japanners' goldsize; 1 gal. (in ¼ gal. tins) terebine; 1 gal. (in ¼ gal. tins) patent knotting

WINDOW GLASS

One crate.

SUNDRIES

Putty (best), picked lump pumice-stone, of each, ¼ cwt.; pumice-stone powder, 14 lb.; glass paper, 1 ream, assorted sizes (Nos. 00, ½, and 1); powder size, ¼ cwt. (best quality); old oil goldsize, 1 lb.; gilders' cushions, knife and 3 tips; gold leaf, 5 books; transferred gold leaf, 5 books; filling-up composition, 14 lb.; paint remover (solvent), 14 lb.; spirit lamp for burning off old paint; paint strainers, 1 doz. (patent detachable gauze); brush holders, 1 doz. (patent suspenders); paint pots and kettles, 12 doz., assorted sizes; stencil pins, 2 doz.; steel graining combs, one set in case; 12 covering sheets (rough sheeting, 2½ yd. wide, cut into 5-yd. lengths); 6 palette knives, 3 putty knives, 3 stripping knives.

PAINTERS' BRUSHES

Ground brushes, size 4/0, 2 doz. (oval shape); English sash tools, sizes 2, 5, and 8, 1 doz. each (best); bevelled varnish brushes, size 3/0, best lily bristles, 1 doz.; bevelled varnish sash tools, size 5, best lily bristle, 1 doz.; distempering brushes, ½ doz. 2 knot, 8 ounce, best quality; stipplers, 2 only, size 8 in. by 6 in.; hog-hair fitches (flat and round), assorted sizes, 2 doz.; lining fitches, 1 doz. assorted, ¼ in., ½ in., and 1 in.; stencil tools, 1 doz., assorted ½ in. and 1 in.; graining mottlers, ½ doz., assorted; graining overgrainer, assorted; badger softener, size 3 in., best quality; dusting brushes, 1 doz.

The total cost of an outfit like this would be from £170 to £180.

Totalling up the above figures, and adding the cost of fitting out the showroom and offices, apart from stocking the (optional) sale-shop, it will be seen that the preliminary outlay necessary to the independent conduct of this business in a moderately good way amounts to a round sum of £200, or thereabouts, including £30 for the showroom and office decorating and furnishing, leaving a moderate balance of £100 in the bank out of the £300 recommended as starting capital with which to meet wages and other current working expenses, pending the receipt of cash returns.

Plumbing. In conjunction with the business of a painter and decorator may be run that of a plumber. Apprenticeships now last about five years, and where premiums are charged they vary between £5 and £50, wages starting at 2s. 6d. a week and rising in the last year of the apprenticeship to 20s. per week.

Technical Instruction. Instruction in plumbers' work may be had at technical schools and institutions throughout the kingdom, and the fees are merely nominal. Examinations are held annually at the schools where instruction is imparted, and certificate awards are made by the examiners of the City and Guilds of London Institute (Department of Technology), South Kensington. Students who are successful in the written examination receive a certificate in the "Principles of Plumbing." Those who pass in both the written and the practical sections are awarded a certificate for "Plumber's Work." Students are recommended to attend a two years' course of instruction before presenting themselves for the preliminary examination, and those who consider themselves competent may enter for the ordinary grade examination without having attempted the more elementary part..

The Plumber in Business. The business of a plumber is not one demanding a large capital, unless it be attempted on an ambitious scale, and with a large stock of material.

The jobbing trade, being the most remunerative, should be cultivated. The price got for labour represents a large profit upon its cost. The wages of workmen vary from 6d. per hour in some country districts to 11d. per hour in London, and their hours from 47 in London to 56½ in some country towns. The price charged for labour, even in towns on the lowest scale, is seldom less than 10d. an hour, and in London a charge of 1s. 6d. an hour is not uncommon. The profits on material are also good—from 33⅓ to 100 per cent. on cost prices—when the work is ordinary jobbing, so that the plumber with even only half a dozen men in his employ may make a very good thing out of his business.

Estimate Work. New work is seldom secured otherwise than by competitive tender, and in most districts such work is cut down in price until profits are bare or non-existent. The new man must take a hand in this game of "beggar-my-neighbour" if he would establish himself. He has the advantage that in his eagerness to make a business he will work hard himself, and exercise a stricter supervision than his competitor claiming earlier establishment. Thus, he may be able to make a profit when the firm in a larger way could not come out of the job with a profit. On the other hand, he may be under the disadvantage of not being familiar with the practice of the architect or clerk of works, who may put him to expense by the arbitrary enforcement of useless clauses in the specification.

A non-remunerative job may often be made to pay by the *extras*, and a knowledge of the habits of an architect in adhering to the details of his specification is worth having when tendering for work under his charge.

Allies of Plumbing Proper. The term *plumbing* has come to be wider in its scope than the mere working in lead and the house sanitary fittings which was the origin of the name. It is usually allied to gasfitting and hot-water fitting, and sometimes to the installation of hydraulic plant, to electricians' work, and to tinsmithing.

The Merchant Side of the Business. Development of the merchant side of the plumber's trade is usually wise, particularly since the trade in incandescent gas fittings began to assume its present large dimensions. The plumber who keeps no front shop neglects an important means of feeding the working department, and allows to go to others trade which he might easily have.

In such things as sanitary fittings, the best method of display is to have a showroom arranged with samples of the best style of lavatory basins, baths, and closets, with water supply connected up. These samples should meet the demands of modern ideas on the subject of sanitation. The sum of £50 plus the labour would pay for fitting up a very fine showroom, say, two baths—one of the shower type—three or four lavatory basins, a similar number of closets, and perhaps a footbath. A tiled floor, and walls of tiles, or of "Emdeca," will add to the expense, but may be worth it and will make a handsome sanitary showroom sure to attract custom. The tile fitting can be done in his slack hours by any workman sufficiently expert. From the roof should be suspended some samples of gas pendants, and brackets should be mounted on the walls. It is unnecessary to carry heavy stocks of sanitary and gas fittings.

Stock of cisterns, faucets, unions, and plumbers' brasswork must, of course, be held in a fully equipped plumber's business. In the sale-shop and windows the public should be shown the latest things in gas lighting. Excellent use is sometimes made of tiny models of sanitary fittings in the window. The competition of the gas companies—municipal or otherwise—may qualify the wisdom of stocking gasfittings upon a heavy scale, but gas mantles and other accessories of incandescent gas lighting can be sold freely in spite of all the competition of companies and corporations.

Buying. The plumber who keeps stock of plumbing materials can usually do better in his purchases than the mere "office" plumber. He is not tied to the merchant so much, and can draw many of his supplies from the manufacturers, thereby securing keener prices. The terms offered by both merchants and manufacturers differ. When the standing of the plumber is known to be good, he can usually get three months' credit, or should he pay monthly or at shorter date—always an advisable course when it is possible—he will secure better terms.

PHOTOGRAPHERS

To become a professional photographer a boy with the proper aspirations should be apprenticed to a good country business when he has reached the age of sixteen. In some cases a premium of £20 to £30 is asked; in others no premium is paid; and, again, small salaries are not unusual. The young beginner is taught printing, toning, developing, and mixing up solutions for a year or so, and is then introduced to the studio, where he helps in the operating, until he is competent to operate himself. Retouching is the last department taught. During these three years the young man should attend evening classes at the local science and art school.

Remuneration. The salaries paid in the business of a photographer are from 30s. to 45s. a week, the amount depending on the experience of the assistant and on his ability as an operator. Many women are engaged in certain departments of the photographer's business. and they are quite successful as reception-room attendants, retouchers, printers, and mounters. The salaries paid to women range from 15s. to 30s. a week, according to experience.

Starting in Business. Whether the photographer decides to buy an existing business or to start a fresh one is a question which circumstances must decide. A photographer who starts a new business can soon make a reputation if he delivers his work promptly. A beginner, however, has often to make his name chiefly by work outside his studio. He will need to cater for work by taking local views, but should make a point of always being in his studio at certain times of the day, or he will never be able to build up a home business. As soon as the business is large enough to support an experienced assistant, most of the difficulties outlined above disappear.

Capital Required. It is hardly possible to state an exact sum as necessary for one starting the business of a photographer. Many have started on £20 or £50, but to start in a fairly comprehensive manner needs from £200 to £300. A studio, for instance, may cost £50 to £100, and the camera from £10 to £30. In the following estimate, a medium class of business has been taken as a basis of calculation:

Portable studio	£60
Furniture and carpets	20
Backgrounds and accessories	20
Camera, lens, and stand	25
Dark-room fittings	10
Apparatus (printing frames, retouching desk, washer, trimmer, rolling press, etc.)	10
Mounts and stationery	10
Plates, paper, and chemicals	10
Miscellaneous (including advertising)	15
Working capital	20
	£200

Premises. The above estimate provides for a portable studio, but it may be that waiting-rooms and dark-room will also have to be provided. Usually these last-named are the ground-floor rooms of a house, and lead to the garden, where the studio is situated. Rents are higher in town, but a business is built up sooner than in the suburbs. Many town business premises are handicapped by having no shop window, the showcases in a doorway being a poor substitute. If possible, have a shop window at disposal. The floor of the shop or reception-room should be linoleum (self-colour), and the walls look nice if papered olive-green, with white paint. The rule should be to avoid a pronounced colour. The furniture must be in good taste if a good-class business is to be cultivated; care should be taken to have comfortable chairs. Adjoining the studio a dressing-room should be provided.

The Studio. The studio is the most important consideration. It must be disposed so that the light is received from the north, or preferably from a north-easterly direction. The length of the studio should be not less than 24 ft. and the width 12 ft., although it is better, if space permit, to make it 35 ft. long by 18 ft. wide. The pitch of the roof is usually 35 to 45 degrees, the height to ridge being about 14 ft.

As regards the studio camera equipment, an average specification would be a 12 × 10 set, to cost, complete, £25. The camera is fitted with a dark slide to take one 12 × 10, one 10 × 8, one 8½ × 6½, two boudoirs, two promenades, two cabinets, and two carte-de-visite pictures. A good portrait lens and massive stand is also included. Many photographers start studio work with an ordinary outdoor outfit, with rapid rectilinear lens, and purchase proper studio apparatus as means permit. The other contents of the studio will be three backgrounds—a reversible neutral-coloured background, and one outdoor and one indoor scene—a headrest, rugs, palms, and grasses, and a few pictures for the walls.

The heating of the studio is best managed by means of a "siphon" gas-stove or by hot-water radiators, and it is essential that the studio be comfortably warm in winter, or successful results cannot be expected.

A dark-room must also be fitted up as described later, but this does not need to be large.

Mounts. The tints of mounts are numerous, but two kinds of mounts are well defined—Bristol and enamelled board. It costs about 5s. per thousand to have the photographer's name stamped on back and front of mounts, the price depending upon whether gold or colour is used.

These should be supplemented by a selection of circles and ovals, slip-in mounts, and mounts with greetings embossed upon them.

Tissue-paper covers for photographs, protector bags, and postal wrappers will be needed, as well as memorandum forms and billheads.

A registration system for negatives must be inaugurated, a ruled book being provided in which the name and address of each sitter is entered, with date and other particulars. The stock of negatives ought to be stored in a dry place, and be kept in order, so that there will be no difficulty in finding a particular negative.

Selling Prices. These vary according to the class of trade. The following are average prices: midgets, 4s. 6d. to 6s. dozen silver prints, 7s. 6d. platino; carte-de-visite, 7s. to 8s. 6d. dozen silver prints, 10s. 6d. to 12s. platino; cabinet, 15s. to 24s. dozen; boudoir, 18s. to 20s. dozen to 35s. dozen; panels, 10s. 6d. to 15s. each; wedding groups, whole plate, one to two guineas, including three to six copies.

Copyright. In the case of ordinary photographs the copyright belongs to the person who pays for the sitting, unless it is expressly reserved by the photographer. A book of forms should be provided for the latter purpose if the extent of the business allows it. The wording of the form is usually something like this:

"In consideration of your allowing me a reduction from your usual terms for taking photographs of me or on my behalf this day, I hereby agree that the copyright in such photographs shall be reserved to you, and that I will not deal in any way with the photographs to prejudice your interest in the copyright."

The reduction should be stated, and the agreement stamped with a sixpenny stamp, dated, filled in with the names of the parties, and witnessed.

Class of Work. Photographer's work is very varied. It includes copying old photographs, enlarging pictures by bromide, carbon, or platinum processes, architectural work, photographic enamels, flashlight groups of dinners, lantern slides, transparencies, picture postcards, and photographs for the Press.

A side-line neglected by professional photographers is the supply of plates, papers, and apparatus to amateurs.

Advertising. Advertising is much neglected by photographers. If more price-lists were distributed, more people would be led to have their pictures taken. Make a special offer of a certain style of photograph or enlargement, but in so doing do not make a mistake of cutting prices; rather make the quality and style better than charge a cheap-jack price. When sending home proofs, enclose a price-list of various styles in which the photographs can be printed, even though the customer has paid for the sitting. In many cases a few additional prints are ordered because some variation in style is fancied

Photographers' Profits. The photographer pure and simple should obtain a gross profit of 50 per cent. on the turnover. A source of much loss with many photographers is the waste of material that goes on. Spoilt plates and paper, and wasted solutions, especially if the last-named contain the precious metals, account for a respectable leakage in profits. The leakage can be stopped by proper supervision and systematic working.

Photographic Materials. Although usually run by chemists, the supply of photographic materials may easily be undertaken by any photographer who has a shop window. There is no apprenticeship in the business, the embryo dealer starts as a junior assistant, and works his way up. Wages are not on a liberal scale; 30s. to 45s. a week are fair averages for junior and senior assistants of experience; and it is not astonishing that any young man of enterprise and small capital soon looks about for a neighbourhood where he can set up in business for himself.

The best neighbourhood is obviously the busy residential suburbs of great towns or seaside resorts. Near public schools a photographic dealer can generally make a living, as successive generations of schoolboys take up the fascinating art.

The Dark-room. In connection with a photographic dealer's business, provision should be made for a dark-room for the use of amateurs. The room should be lighted by sliding shutters on the window, and the source of light for the ruby lamp should be gas or electric light. Means must be adopted for obtaining white light at will, as some printing processes require a white light for a few seconds at a time. A by-pass is a useful addition to the gas burner, but with electric light a separate lamp for white light is readily fitted alongside the ruby lamp. The walls should be painted a dull lead colour, the same treatment being applied to the ceiling. Water should be laid on, and beneath the tap should be a porcelain or lead-lined sink. The tap to the water-pipe should be fitted with a reducing nozzle, and a rose cap is an advantage.

The developing space should be on one side of the sink, and arranged so that splashes of developer and water drain away to the sink. Shelves underneath the sink and the developing bench should be fitted up for the dishes, while on the walls shelves are placed for the developing solutions and measures. Another table should be provided for the dark-slides while filling them or while the plates they have contained are being developed. This table should be arranged at the opposite side of the room from the sink, so that it is not likely to get splashed.

The room should be well ventilated. Any carpenter will understand when it is explained to him that he must make the ventilators light-traps. The inside of the door also must be trapped round the edges, but this may be rendered unnecessary by the provision of a curtain on the outside. The door should lock on the inside, so as to prevent the possibility of disturbance at critical periods of plate changing or developing. A refinement in dark-room doors is to have two doors separated by a lobby, so that a person can enter the room without admitting light. To casual customers a small charge —minimum, 6d.—is made for the use of the dark-room for plate changing, but if the customer be also a purchaser of goods at the shop it is unwise to press the charge. When the room is used for developing plates a charge of 1s. is made, this amount covering the use of the room for an hour.

Capital Required. The amount of capital required for starting the business of a photographic dealer depends upon whether it is to be subsidiary to another business or to be mainly photographic requisites. When started in connection with a photographer's or drug business, a ten-pound note would suffice to stock the most frequently required apparatus and plates, the chemicals being already articles of stock. Great care must be taken not to lay in a stock of plates and papers that will last beyond the season, as these goods do not keep well.

When a new business is being started, the amount of capital will depend, in a measure, on the neighbourhood, but £100 is a medium figure. For this an excellent assortment of cameras, lenses, shutters, stands, view-finders, handbooks, dishes, racks, tanks, plates, ruby lamps, mounts, negative boxes, chemicals, trimmers, scales, bottles, papers, etc., can be secured.

Side-lines. It is becoming increasingly popular for amateurs to hand over their exposed plates or films to the photographic dealer for development and subsequent printing. Some amateurs do their own development, and hand the negatives over for printing. The profits are from 20 to 25 per cent. on this class of work.

Repairs to cameras and apparatus should be undertaken, and arrangements made with a manufacturer for promptness in carrying out this work.

The hire of cameras is another branch of the dealer's business. A few good cameras accumulate through being shop-soiled, or possibly by exchange with a customer requiring a new instrument. The cameras should be in perfect order, and if the

customer is unknown a deposit up to the value of the apparatus should be insisted upon. The charge for apparatus is 5 per cent. of the value of the camera per week, with a minimum of 5s. The charge for the hire of a camera for a single day should depend on the class of apparatus, but a minimum should always be fixed, as the convenience of hiring is one for which a customer should expect to pay.

Lantern slides are let out on hire at many large photographic dealers', the charge for the hire of a set of slides being from 1s. to 2s. per night, the customer paying carriage.

Picture framing is suitable for this business, as photographic enlargements are generally incomplete without a frame.

Profits. The profits in the photographic dealer's business, as distinct from that of the mere photographer, are good, but this should be qualified by the statement that much soiled stock is likely to accumulate if business is not brisk. The sale of such stock is, perforce, done at reduced rates, and, consequently, is profitless in some senses. On apparatus and accessories 33⅓ per cent. profit is allowed, varying with the kind of goods, but some proprietary articles allow a profit of only 10 to 15 per cent.

SADDLERS

The trade of a saddler and harness-maker seems to have fallen on evil days. The automobile is ousting the horse from the high-roads, and one of the attendant results is the lessened occasion for purchasing saddlery and harness by those who were wont to be the most liberal in their disbursements upon such articles.

Apprenticeship is general and necessary. The term of service was formerly seven years but it has become shorter in recent decades, and five years may now be regarded as the most usual term. The period is none too long, as there are a great many practical details to be learned, and the youth who has just completed his apprenticeship is never a thoroughly qualified craftsman. He must gain further experience for at least three years—preferably in a shop other than that in which his apprenticeship was passed—before he can claim thorough competence.

Sometimes a premium is required by the employer, but this is now rare, as the condition of the trade makes it difficult for employers to obtain apprentices even without the premium. Apprentices' wages vary. In many country districts they begin at only 2s. a week, rising to 9s. during the last year, but in London the wages during the first year are usually 5s. a week.

Journeymen Saddlers. The wages of journeymen saddlers are from 20s. to 40s. per week, and 30s. is about the average. The journeyman saddler frequently has no opportunity to learn the commercial side of the business, his time being spent exclusively, or almost exclusively, at the bench, but he should endeavour to obtain some commercial knowledge, say, as the manager of a branch business, or as assistant to attend customers or to buy goods and materials.

The Departments. The departments, if we may call them so, of the saddlery and harness business are three—the manufacturing, the selling, and the repairing. The saddler need never be idle. If his attention is not required by a customer, he may be doing repair work; and if neither selling nor repairing be possible at the moment, he may be making something for stock.

Capital. Many saddlers start in a small way of business, with a capital of not more than £100. With only this amount at disposal the selling stock must be small, as the greater part of the sum must be spent in working material, which is expensive. To open a medium-class business, the sum of at least £250 is required, and we may take this as a typical case for consideration. With such a sum financial pressure will be felt in intensity as the volume of business is great, because credit prevails to such a large extent, and the saddler can seldom receive payments as promptly as he has to make them. The premises required must be commodious, but need not be in the principal thoroughfares if rents are too high, as the orders are usually given by coachmen and grooms, and not by their masters. The shop-fittings are not elaborate or expensive—a strong, solid bench at which to work, a counter upon which to cut out and from which to serve customers; a few glass wall-cases for the better-class stock, such as bits, spurs, stirrup-irons, whips, and brushes; plenty of hooks and brackets from which to suspend harness, a dummy horse, a rail to show saddles, a supply of wooden shelves placed at different heights, and a small desk. All these, with the necessary working tools, would absorb, say £50 of the capital. The rest of the money, or the greater portion of it, would be spent upon the raw materials of the craft and upon stock, such as whips, horse-rugs, sponges, low-priced collars, and saddles, and proprietary articles, such as embrocation and harness composition, etc.

Full details of the methods of manufacture are given under Saddlery and Harness-making on page 4223 and the following pages.

Sundries. The list of saddlers' sundries is numerous. It comprises:

Brushes of all sorts, body brushes, whisk dandy brushes, whalebone dandy brushes, bass ditto, water brushes, spoke brushes (with and without handles), mane brushes, harness and boot brushes, breeches brushes, compo and carriage cushion brushes, cloth brushes, carriage washing brushes, oil and hoof brushes, dog and stable brushes, horse toppings, gig lamps, sponges, chamois leathers, creams, revivers, burnishers, and glove brushes; nose-bags, halters and halter reins, stable fittings; horse clippers, singeing lamps, scrapers, curry combs, mane combs, stable baskets, buckets, coaching baskets, etc.; corn servers and measures, whips, hunting crops, whip sockets, thongs, whipcord, etc.; body belts, girths, singlets, rugs, horse nets, bandages and rubbers, horse boots, knee-caps, body rollers, horses' bonnets, etc. Blackings, dubbins, polishes, cleaning pastes, embrocation oils, soaps, etc. Unfortunately, the last-mentioned articles are usually sold at cut prices by the stores and grocers. The saddler must protect himself by buying in the best market and making up his own blackings, dyes, etc., and by pushing their sale.

Side-lines. Leggings and gaiters are very profitable, and dog collars, leads, chains, baskets, and clothing are very saleable, if a little less remunerative. Bags and portmanteaus are intimately allied to the trade, and should by all means be put into stock. Driving-gloves are articles of frequent demand, and yield good profits. Saddler-made purses have a reputation for long life which they deserve, and are not to be despised.

Credit and Profits. As already mentioned, the business is chiefly of the credit order, and yearly and half-yearly accounts are the rule. The trading, both on the sales of articles bought and on the manufactured work, should show a gross profit of about 33⅓ per cent. on the return. Repair work ought to be more remunerative, chiefly for the reason that the proportion of material used is generally small, and the price is made up of labour, which should always carry a larger profit than merchandise.

The Tools and Materials Used by Painters, Paperhangers, and Glaziers. The Methods of Executing Various Kinds of Work.

PAPERING, PAINTING, AND GLAZING

PAPERHANGING

THE work of the paperhanger consists in preparing the surfaces of walls and ceilings, trimming and preparing paper of various kinds and other hangings with which in these days walls are frequently ornamented and in some cases protected.

Paperhangers' Tools. The tools used by the paperhanger are not very numerous. One may include with them overalls, which are generally made of "duck" or "drilling," which are always worn by the paperhanger and which are formed with pockets for rule and shears and a wide pocket across the front. *Shears* [18] are required for trimming papers before hanging; long ones are from 14 in. to 16 in. long, but shorter ones are also required. A *trimming knife* [19] is required of thoroughly well tempered steel; this has a deep blade with a rounded cutting edge, and is made in one or two different forms. It is used against a straightedge when trimming. A *cutting wheel* [20] is often used. This is really a circular knife with a thin, fine edge, which may readily be kept in a sharp condition. A variation of this knife, known as the *twentieth century cutter* [21], is provided with a ratchet. When the wheel is drawn forward it becomes locked, and a definite portion of the circumference acts as the cutting edge; by pressing the wheel backward it rotates slightly, another cog of the ratchet becomes locked and a fresh part of the circumference comes into play, so that a keen edge may be in use until the whole circumference has been brought into play, when it must be re-sharpened. These cutters may be used for trimming paper either dry or pasted.

There are various machines for trimming paper in long lengths before it is pasted, and these are made to trim one or both edges at once for any paper up to 22 in. wide. The *Empire trimmer*, made by Mr. J. Oates, of Huddersfield, has a rod in front of the machine on which the roll to be cut is placed, and a second roll at the back on which it is wound after cutting. The position of the cutting wheels can be adjusted to the exact width required.

Trimming Wallpapers. Great care is required in handling rolls of paper that have been trimmed mechanically; this is usually done at the shop, and if the rolls are afterwards taken to the job and made to stand on their ends, the carefully-trimmed edges will be damaged. Ordinarily, trimming is done on the job just before hanging, and all such damaged edges are removed by trimming; this operation is carried out on a trimming table erected on a pair of light trestles.

The *smoothing brush* [22] is a broad brush from 10 in. to 14 in. wide with a wooden back grooved to allow of its being held readily; these brushes are generally made of white Russian bristles.

Seam rollers are used for smoothing joints and are made of rosewood or ivory or of rubber [24], or they may be finished with a layer of felt, covered with muslin, which may be readily renewed when soiled. The width of the roller is from 1¼ in. to 2 in., and the surface is either cylindrical or barrel-shaped. In order to get close up to the work round the edges of architraves to doors and windows, and in similar positions, a *side arm roller* [25] is employed.

Smoothing rollers [23] are usually about 8 in. wide and are used for running over the general surface of work. They are sometimes made of polished hardwood mounted in nickel-plated frames; but in many cases these are also finished with a layer of felt, which is covered with muslin held in position by rings at each end.

The *brushes* [26] used by the paperhanger are made of long grey bristles mounted in wood handles so that they form a flat kind of brush from 6 in. to 8 in. wide.

A *size kettle* [27] is best provided with a water-jacket to prevent any possibility of the size being burnt when heated.

The paperhanger requires to use a plummet, a chalk line, a 2-ft. rule, a pail for paste, sandpaper, a tape measure, and compasses, and, very usually, cloths for smoothing down the paper in place of the smoothing brush already described.

Wallpapers. *Wallpapers* are made by various processes and are sold by the piece. In the case of English paper the piece is 12 yd. long nominal, and the paper is about 22 in. wide as sold, and 21 in. when trimmed for hanging, and has a superficial area of 63 sq. ft. French papers vary somewhat in length, but are usually 9 yd. long and 18 in. wide, and contain 40½ sq. ft. American papers are 8 yd. long and 18 in. wide, and contain 36 sq. ft. The pattern of a paper must therefore be made to repeat once or oftener exactly in the width of the roll. Borders and friezes are usually sold by the yard.

Papers that are printed are either machine printed or hand printed. The best results are obtained by hand printing, which is done from wood blocks; these papers may be known by the presence of a white margin at each end of the roll, as well as at each edge; this results from printing each piece separately, whereas machine-printed papers are printed in immensely long rolls and afterwards cut up into lengths, so that the pattern runs out to the very end. The colours in machine-printed papers are not always so well set as in the case of those printed by hand.

Pulp papers are the commonest class of papers; in these the paper itself may be a tinted paper and the pattern printed in colour, or in better papers both the ground and the pattern are printed.

Satin papers have a glazed or polished surface, giving an effect like satin; this is produced by mixing Spanish white with the colour and then thoroughly burnishing the surface. This class of paper is somewhat susceptible to damp, and it is often desirable to line the walls with lining paper before hanging it; but these papers usually keep a clean surface, as dirt does not readily adhere to them.

Flock papers have the patterns printed on a ground with an adhesive substance, and upon this shearings of wool or silk, very finely divided, are sprinkled, and these adhere, forming a raised pattern; the

wool flock gives a somewhat cloth-like or velvety appearance; the silk a somewhat glistening effect, and striped silk flocks are a good deal used.

Sanitary papers are printed from copper rollers in oil colour mixed with a strong adhesive material; such papers, when hung, may be washed, which is not possible with ordinary papers.

Ingrain papers, which are not printed, but coloured in the manufacture, are prepared in various tints, with a slightly mottled surface, and are rather soft and porous; papers are also made to imitate tapestry and other textile fabrics.

Special Wall Coverings. There are many other forms of wall hanging now in use, which are of a more substantial and permanent character than the ordinary wallpaper. They are, as a rule, considerably more expensive in the first instance, and require special treatment in hanging. Some of them are supplied decorated ready for hanging, others can be obtained perfectly plain for decorative treatment after fixing.

Japanese leather papers are thick in substance, usually slightly embossed, and decorated in colours with which a good deal of metal bronzing or gilding is included; these papers are usually supplied in rolls 36 in. wide and 12 yd. long, and in the majority the design is rather large in character.

Lincrusta Walton is a material generally modelled solidly in relief, and is produced in a great variety of designs suitable for dados, wall surfaces, friezes and also for ceilings. It forms an excellent base for colour decoration, and some of the designs in high relief may be treated plainly in one colour, a good effect being obtained by the contrast of light and shade without any picking out. *Cordelova* and *cameoid* are other forms of material manufactured and supplied by the same firm, and are also made in both low and high relief; in the latter form, when used for ceilings, they may be arranged to give the effect of plaster panelled ceilings.

Lignomur is another material with the design formed in relief. It is manufactured of wood fibre, and is embossed in hollow relief; it may be applied to walls or ceilings, and afterwards decorated in a variety of ways, either in oil colour or distemper, or it may be stained and varnished, as if it were a natural wood.

Anaglypta is also moulded in relief, both high and low, and is made by pressing pulp or plastic paper into moulds.

Tynecastle canvas is very extensively employed, and is also modelled in hollow relief, canvas being employed as the basis of this material; very bold relief is possible, and the material lends itself to decoration in colour after hanging.

Woven Wall Coverings. Woven and embroidered fabrics, used as hangings or mounted on frames, have long been used for covering walls, and come rather under the upholsterer's department than the paperhanger's. The drawbacks to such materials—their liability to become soiled, the difficulty in changing them, and the extent to which they may harbour dirt, and even vermin—have been serious drawbacks to their admirable qualities from the decorative and artistic points of view. In recent times, some of these materials, the texture of which is admirable, have been prepared so that they may be applied to the wall by the paperhanger practically in the same way as a wallpaper. To render this possible, the space between the fibres must be filled, and especially the back, so that it may adhere solidly to the wall, and not allow the paste to work through to the surface; the material itself must be dyed and fixed so that it will not readily fade.

Burlap, made from jute, is extensively used for this class of work; the fibre is lustrous, and the material strong and not very expensive, and admits of the surface being treated in colours, which may be either printed or stencilled on it. The material can also be obtained in very wide widths, so that it is possible in many cases to get a material the width of which will equal the height of the wall space, and which may be run round the walls without many joints; where there are not many openings or recesses to be dealt with, they may be readily cut out of the material. This material may be used in narrower widths as a dado or frieze in combination with papered walls, or as a filling to panels.

Prepared canvas may be applied in a similar way to walls and ceilings, and afterwards decorated in either oil or water colour, and either of these materials not only forms a suitable decorative surface, but prevents the appearance of surface cracks, such as frequently arise with ordinary plastered ceilings.

Calculating Paper Required. The paperhanger is required to estimate the amount of paper required for any particular piece of work. The experienced man can tell pretty closely without measurement the number of pieces required for any particular room, but it is easy to ascertain the superficial area of the walls of any room, and, bearing in mind the amount of paper in a roll, already given, to see exactly how many pieces will cover it. But allowance must also be made for waste; this occurs not only in fitting paper round door and window openings, fireplaces, and recesses, which often accounts for a good deal, but there is also often considerable waste in cutting up paper so as to ensure that the pattern shall match exactly when two pieces are hung side by side. If the pattern is small, so that in height it exactly repeats every few inches, this loss will not be great, but if the pattern is large, and only repeats once or twice in the height of the wall, it may easily happen that a considerable amount may have to be wasted for every length cut from the roll. It is usual to allow one extra roll for each five to eight rolls required exactly to cover the wall, the specific allowance depending on the probable waste.

Trimming Paper. Wallpapers are delivered in rolls with a margin on each side, which must be trimmed off before the paper is hung. The machines used for trimming have been described, but the old-fashioned method of trimming, by means of a large pair of scissors or shears, still prevails. The roll of paper is laid on the trimming-board and unrolled, trimmed with the shears on one edge, and re-rolled during the operation, which is repeated for the other edge.

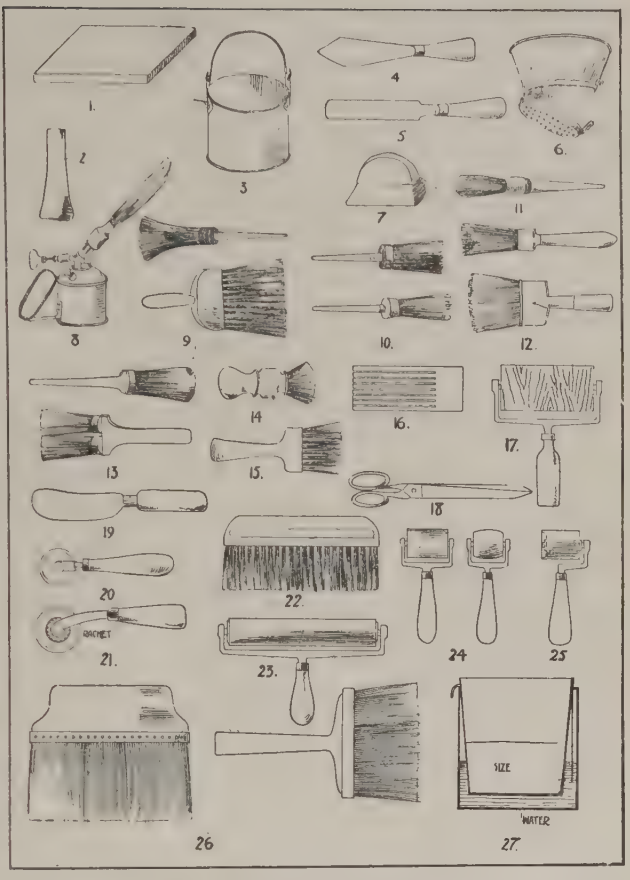
Preparing the Walls. In the case of new walls, the surface should be sized with glue size [see Painting, page 5497]. It is well to point out that in the case of most plastered surfaces the lime in the plaster is very liable to act on the colours used for printing designs on wallpapers, and also on ingrains, and destroys them. This action is worse if there is any damp, but may occur even with dry plaster, and may continue for several months at least after the wall is plastered. It is particularly likely to affect green and some other delicate tints, and it is desirable, as a rule, not to hang an expensive wallpaper on new walls within twelve months of the plastering, but to cover them temporarily with a tinted lining paper, or to distemper them.

In the case of old walls, it is important that the old paper should be stripped; if this is not done, the dirt, and possibly disease germs, in the old paper will only be covered over. Paper may be removed by washing it over with hot water, and then scraping it off, taking care not to damage the plaster. Paper that has been varnished after hanging is often very difficult to remove. A coat of hot paste applied to the surface will, as a rule, soften it, but a special varnish remover may be required, and in some cases where the paper was porous the varnish penetrates to the plaster, and it is almost impossible to remove it without destroying the plaster surface.

A varnished surface does not hold either dirt or germs to the extent that an unvarnished paper will, and the surface, if it is left, may be cleaned, and the joints rubbed smooth with pumice; the surface may be prepared by giving it a coat of brown sugar mixed with water in the proportion of 2 lb. of sugar to 1 pail of water.

Repairing Walls. In the case of old walls, all nails must be extracted and any defects in the plaster made good. This is properly the work of the plasterer, but the paperhanger may often have to execute small repairs. Such repairs are usually executed in plaster of Paris, or in plaster mixed with fine lime putty [see Plastering], and care must be taken to see that the surface of the repair is truly in the same plane as the general wall surface.

When plaster has been damaged by blows, which is liable to occur—as, for example, by the handle of a door opened back against it — ordinary repairing in plaster is useless. In such a case the plaster may be neatly cut out in the form of a square, and a piece of wood let in, screwed if possible to wood plugs let into a brick wall, or to the quarters of a partition, but in some cases merely to the laths. In this case, also, care must be taken to see that the surface is uniform with the wall, and if sunk a little below it, the extra thickness may be made up by pasting one or more neatly cut sheets of paper over it.



PAINTERS' AND PAPERHANGERS' TOOLS

1. Grinding stone 2. Muller 3. Paint-pot 4. Stopping knife 5. Palette knife 6. Strainer 7. Felt rubber 8. Painters' torch 9. Dusting brushes 10. Ground brushes 11. Sash tool 12. Varnish brushes 13. Distemper brushes 14. Stencil brush 15. Badger softener 16. Grainer's comb 17. Graining roller 18. Shears 19. Trimming knife 20. Cutting wheel 21. "Twentieth Century" cutter 22. Smoothing brush 23. Smoothing roller 24. Seam rollers 25. Side-arm roller 26. Paste brushes 27. Size kettle

Paperhangers' Paste. Pastes are employed by the paperhanger varying in strength with the class of material to be used. The following recipes are given in Rivington's work, and the best white wheat flour should be used as the basis of them all.

No. 1. Beat up 4 lb. of flour in cold water to a stiff batter, getting rid of all lumps; add enough water to bring it to the consistency of pudding batter. Pour boiling water over it, stirring rapidly; when the mixture swells and loses the white colour of flour it is ready for use.

No. 2 is made like No. 1, but, just before the boiling water is added, 2 oz. of alum are mixed with the batter; this hardens it and is a good preservative. This form of paste may be used for flock papers, but alum must not be used with gilt papers, as it turns the metal dark.

No. 3. Make a batter as in No. 1, but of less consistency, and to 2 qts. of batter add ½ oz. of powdered resin. Set the mixture over a moderate fire, stirring it till it boils and thickens; allow it to cool, and thin it with thin gum arabic water. This is used when strong adhesion is required, and is useful in papering over varnished or painted surfaces.

No. 4 is the same as No. 3, but without the gum arabic, and is used for securing the edges of flock papers.

Some special pastes for hanging heavy goods will be described later.

Hanging Wallpapers. Quite apart from the mere mechanical part of hanging there is need for a good deal of judgment in the setting out of the paper so that it will look well on the wall; it often happens that by shifting the paper up or down a few inches the effect may be considerably improved, or the reverse. It is very important also that any well-marked pattern should be properly centred in the most prominent feature in any room; this is very usually the chimney front. This careful

centring is, if possible, of even more importance in papering ceilings, for the whole expanse is seen at once, and if the pattern is not set out centrally in the room a very bad effect is produced.

Special care must be taken to see that the first strip hung on a wall has the edges truly vertical, and a line and plummet may be used to set out a vertical line, which may be marked on the wall surface with chalk.

Pasting the Paper. A length is cut off from the roll a little longer than the height between skirting and cornice, laid face downwards on the table, and the back pasted over uniformly and not too thickly, working from the centre outwards. After pasting, the ends are folded back towards the centre, the edges being kept even; if the strip is too long for the table, one end is first pasted and then folded over, then the paper is drawn along and the other end pasted and folded. The actual hanging requires skill and experience. The upper edge is usually cut exactly, and is fitted against the cornice mould or picture rail, and the upper half of the paper unfolded, placed in contact with the wall, and brushed down with a cloth, brush, or roller; care must be taken not to work the paste towards the outer edge or it may be forced out in lumps. When one piece is hung it serves as a guide to the others, which are added right and left. In hanging the last piece there may be some difficulty in matching exactly the patterns at the joint, especially if the design is large, and any such irregular join should be contrived where it will be as little obtrusive as possible. Where an angle occurs it is often found not to be quite straight, and it is best to cut the paper so that a join will come close to the angle and not to use a whole width. When each strip is hung the bottom edge usually overhangs the skirting slightly, and when it has been rolled or brushed down close to the bottom the lower end is lifted slightly, the point of the shears drawn along to mark the exact length, and it is then trimmed and afterwards pressed down. The narrow rollers are used for the joints. The joints are usually formed by butting one piece of paper close to the next piece, and where this is done both edges must be trimmed; in common work one selvedge is left on and the edge of the next piece pasted over it, but this causes a ridge at the joint. In arranging ceilings the paper should be set so that the joints run in the direction of the window, or if there are windows on adjoining walls then towards the strongest light. Where a good class of paper is hung on new walls they are often first hung with lining paper and then with the wall-paper itself.

Hanging Special Wall Coverings. Where heavy, embossed papers are employed it is usual to prepare the wall by hanging strong brown paper as a lining. In the case of most kinds of special hangings full instructions are issued by the makers and these should always be observed.

Lincrusta Walton, if the weather is cold, should be placed in a warm room before it is unrolled. The edges must be trimmed very carefully, using a metal-edged straightedge and a sharp leather-cutter's knife, which is stiffer than a paperhanger's. The paste is used hot and the lengths, after pasting, are applied to the wall, and well rubbed with a stiff, short hairbrush, or a soft, spherical rubber roller. If blisters appear they must be pricked and then rubbed down. The paste may be ordinary paste mixed with half the amount of glue, but the following composition is recommended by the makers: French plaster of Paris, 4 lb.; raw linseed oil, 1 pint; these are rubbed together through a sieve; 1 lb. of white glue is well boiled in 1½ gallons of water and poured in hot, and the whole left to get cool, being stirred to thoroughly mix it.

Anaglypta is trimmed with a metal straightedge and pasted with ordinary paste; after about fifteen minutes it is again pasted with stiff paste containing from ⅛ to ¼ glue, hung at once, and pushed home with a cloth.

In hanging *Lignomur* no glue must be used, but the paste should be as stiff as it can be made. Tynecastle canvas is treated in the same way as Lignomur, but it is not necessary to mix glue with the second coat of paste.

Japanese leather papers are hung with ordinary paste, applied to the paper as a first coat, and after two or three minutes a second coat is applied, mixed with a proportion of glue.

PAINTERS' WORK

The work of the painter consists in covering perishable or common materials with a thin material that will protect them from decay, enable them better to resist ordinary wear and tear, or give to them an improved appearance.

Painters' Tools. The painter's tools are comparatively few in number. A *grinding stone* [1] is required for grinding colours; this is usually a slab of marble about 2 ft. square; the *muller* [2] is about 7 in. long and 4 in. in diameter, and is of granite or other very hard material. Where paint is required in large quantities it is, however, ground in a mill. There are also *pots* of earthenware or tin for holding colours of various sizes, a *pallet* to hold small quantities of colour for use in letter writing and small decorative work, and a *mahlstick*, used as a rest for the hand in letter writing and small decorative work.

The *stopping knife* [4] is one with a stiff blade set in a wooden handle. From the handle the blade broadens outwards, the back is straight till the broadest point is reached, and the end is rather sharply pointed; the lower edge is without a sharp angle, but is slightly rounded so as to form the point. This tool is used for *stopping* surfaces that are to be painted—that is, filling in any small holes with putty or other special stopping.

The *palette knife* [5] is one with a long, broad, flexible blade, parallel sided, and with a rounded end fixed in a wood handle. It is made in several sizes and is used for mixing paints.

The *painter's can* [3] is a circular metal case with a flat bottom and a movable handle of iron, by which it is carried; it is used for mixing paints and for containing them during use.

A *strainer* is used for straining paint after it has been mixed, and, before use, to rid it of all irregularities and lumps. Strainers are of various forms: the simplest resembles an ordinary colander but with a flat bottom, which is perforated with very fine holes, through which the paint is passed, a stick or brush being employed to work it about and assist it through. Another form [6] has a hinged bottom perforated with large holes, and over these a piece of muslin or cheesecloth is strained, and this material, if it becomes clogged with particles of paint, can be renewed at any time.

The *felt rubber* [7] is a flat tool formed at the back into a handle and covered with felt, and is specially used for rubbing down varnished work.

The *painter's torch* [8] is a small lamp, producing a strong flame with a forced draught, which is used for burning off paint, and can be held in the hand and moved over the surface of the paint to be

removed; where gas is available a burner on the principle of a Bunsen burner, producing a flat flame, may be used for the purpose.

Brushes are the most important tools the painter uses, and with these the material is actually applied to the surface to be covered; they are made in various sizes and forms, depending on the nature of the material to be employed and the method of using it. Good brushes, if properly cared for, will last a long while, and it is desirable they should be of good quality and made by a firm of standing.

Dusting brushes [9], both round and flat, are required to prepare work for painting; like other brushes these are provided with wooden handles, are of different sizes, and are kept dry for dusting only.

Brushes for applying paint differ much in size and form, each class of brush being made in a series of sizes, which are regularly numbered.

Ground brushes [10] are fairly large brushes employed for large, plain surfaces and are made round or oval in form; they are formed of hogs' bristles and are well bound round at the base with twine to keep the bristles compact, or have patent metal ferrules.

The *sash tool* [11] is a smaller class of brush, used for painting mouldings, sash bars, and similar work. These are also made in different forms, but an oval-shaped brush is very generally used.

Varnish brushes [12] are either round brushes brought to a broad thin edge or are broad brushes mounted in a metal frame.

Distemper brushes [13] are large brushes used for whitewashing and distempering; they are termed *one-knot* or *two-knot*, according to the manner in which they are made up; and flat brassbound brushes are also employed for this work.

Stencil brushes [14] are used for stencilling designs in distemper, and are short metal-bound brushes.

A *badger softener* [15] is a brush used in graining work to give a woody appearance to the work.

Care of Brushes. It is important that brushes, if they are to be kept in good working order, should not become caked with paint. It is not necessary to clean brushes after a day's use if they are to be used again within a day or two, but they should be suspended in raw linseed oil or in water to keep them moist, and so that the points do not touch the bottom of the vessel; for if the bristles rest on the bottom they are apt to be bent.

The oil or water can readily be squeezed out of the brush by drawing it firmly across the edge of a piece of board when the brush is required for use. If brushes are to be out of use for some time, they must be thoroughly cleaned in turpentine or with soap and hot water, dried, and afterwards wrapped in clean paper and put away in a dry, cool cupboard.

Grainers' combs [16] are required for work to be grained, and these are made in various degrees of fineness.

Graining rollers [17] are employed for some kinds of graining. The colour is supplied by a brush to a series of discs on the roller, which are notched at intervals, and produce dark broken lines in the work, or the roller may have the pattern of the grain incised on its surface.

Pumice-stone is used for rubbing down work before applying fresh coats of paint, and fine glasspaper is used in a similar manner.

Paint-spraying machines consist of a pumping apparatus attached to a hose fitted with a perforated nozzle; they are chiefly used for distemper, lime white, etc., and the material is sprayed on to the surface very rapidly and evenly, and reaches all crevices or irregularities.

Painters' Materials. The materials used by the painter are either opaque, so that they entirely cover and conceal the real surface of the material, or they are transparent or semi-transparent, allowing the natural surface to be visible.

Of opaque materials, those in most general use are termed *paints*, and when mixed ready for use are usually made up of *vehicles* (which are liquid substances holding other matters in suspension, and permitting of their even distribution over the surface), *driers*, which are oxidising substances enabling the vehicles to dry rapidly, and *pigments*, or colouring materials. Pigments are finely powdered, and held in suspension by the vehicles.

Vehicles are of different kinds. For water-paints, ordinary water is used, and this class of vehicle is employed not only for water-colour drawings, but for whitewash and distemper. For most painted work, however, the vehicle is either a fatty or fixed oil—that is, one that cannot be distilled, or a volatile oil that may be distilled; and not uncommonly both these classes of oil are employed in mixing paint for use.

Oils. *Linseed oil* is the most usual of the fixed oils, and is obtained by crushing the seeds of the flax plant. In common with other fixed oils, it does not dry by evaporation but by the absorption of oxygen, and during the process attains great toughness and flexibility. When applied to wood surfaces, it sinks into the pores of the wood, and hardens, forming a protection from the weather.

Raw linseed oil is the oil in its natural state. In this condition it is of a bright amber colour, and dries somewhat slowly. If spread in a film on a non-absorbent material it takes from two to three days to dry; the bright colour makes it unsuitable for mixing with delicate shades, and if it is to be used for such work it may be clarified with oil of vitriol, which must, however, be afterwards washed out. The material improves in quality and colour by keeping for some years, and should not be used until it has been kept for six months at least; it is generally employed for most internal work in which linseed oil is the vehicle and for grinding up colours.

Boiled linseed oil absorbs oxygen more rapidly than the raw oil. The process of boiling consists in heating the oil (which does not actually boil) to about 200° F., and then adding to each gallon of oil about 1 lb. of red lead and 1 lb. of litharge, and raising it to a temperature of 400° F., which is maintained for two or three hours. If a dark-coloured oil is required, umber may be added also during the boiling process. The oil, after boiling, is drawn off and allowed to settle, and is then bright and clear, but darker than the raw oil.

If the oil is to be mixed with zinc-white as a pigment and not white lead, the oxides of lead should not be used in the boiling process, but about 5 per cent. by weight of powdered peroxide of manganese is substituted, and the oil is afterwards filtered. The drying and the colour of raw oil may be improved "by adding about 1 lb. of white lead to every gallon of oil, and allowing it to settle for at least a week" ("Builders' Work"—Seddon).

The boiled oil dries more quickly than the raw oil; if spread on a non-absorbent material it should be quite dry in from twelve to twenty-four hours. It is particularly well suited to external work, when rapid drying is of great importance, and in which tints of a delicate nature are rarely called for.

Poppy oil is extracted from the seeds of the common poppy; it is inferior to linseed oil in both tenacity and in its drying qualities, but is very

nearly colourless, and is therefore sometimes employed for mixing with delicate tints in internal work.

Nut oils are usually extracted from walnuts, and are cheap, but not durable, and are suited only for internal work of a temporary character.

Turpentine. *Oil of turpentine*, also known as *spirits of turpentine*, abbreviated commonly into *turps*, is a volatile oil obtained by distilling turpentine—a resinous exudation from certain trees which contain resin and oil of turpentine. This oil has a strong odour, and when exposed to the air absorbs oxygen, and is converted into a substance resembling resin. It is used as a solvent for gum resins, and also for mixing paints in combination with linseed oil, or by itself when a flatting coat is required—that is, one without a glossy surface. When spread on a non-porous surface it should dry in twenty-four hours, leaving a hard varnish on the surface.

Strasbourg turpentine is produced from the silver fir, *Venice turpentine* from the larch, and *common turpentine* from the Carolina pine.

Driers. *Driers* are mixed with paints to assist the drying of the vehicles when this is necessary. The drying of linseed oil is produced by the absorption of oxygen as already mentioned, and the driers which are usually employed are materials rich in oxygen, and readily yielding up the oxygen to the oil, thus hastening the process. The action of some of the pigments to be hereafter described is to retard the drying process, and driers are specially valuable when such pigments must be used in mixing paints, otherwise the paint would continue for a long time in a semi-dry condition, known as *tacky*. During this time it is slightly sticky, or adhesive, if touched.

The most usual driers for use with light tints are *acetate* or *sugar of lead* and *sulphate of zinc; litharge*, or oxide of lead, which is produced during the extraction of lead from its ores, is very commonly used for all darker tints. For use with lakes, *japanners' gold size* is used, which consists of oil boiled in litharge. For use with zinc-white, *sulphate of manganese* is an efficient drier, a very small quantity sufficing; but care must be taken in mixing it or the paint may be spotted. Another drier used with zinc-white is that made by adding about 10 per cent. by weight of a mixture formed of boiled linseed oil (20 parts) and peroxide of manganese (1 part). It is important to select a drier suited to the pigment to be used, and to observe the following points, which are taken from Seddon's "Builders' Work."

1. Do not use them with pigments that dry well in oil colour.
2. Do not employ them to excess, which would retard the drying.
3. Do not add them to the colour till just before it is used.
4. Do not use more than one drier with the same colour.
5. Avoid the use of patent driers.

The result of using driers in excess may be the drying of the surface with abnormal rapidity, so that a thin skin is formed which, at a later time, may become softened by the action of the undried paint behind it, and remain tacky for a long time. Patent driers are in the form of paste, and are slightly more economical than the ordinary liquid driers, but vary much in quality and in their effect on the paint.

Pigments. *Pigments* are the solid matters introduced into paints to give *body*—that is, solidity—substance, and opacity to the paint, and also to give to it any desired tint or colour. They are in most cases earthy or metallic carbonates and oxides, and are very finely ground; they are sold in a dry form as powder, and also ground up in oil. They may be divided into two main classes—namely, *bases*, which are used to produce body and opacity, and *colouring pigments*, which are used to produce various tints and colours, especially in the finishing coats.

Bases. *White lead* is prepared by various processes. The Dutch process produces the best, and consists in placing gratings of pure lead in tan. The fumes of acetic acid are allowed to act on these, which become corroded and covered with a crust of *carbonate of lead*, which is commonly known as *white lead;* this is removed and ground and forms a heavy powder, which becomes grey if exposed to the air. The substance may also be prepared by passing carbonic acid through solutions of various salts of lead, but the material thus precipitated has no density, and absorbs more oil than that produced by the other process.

White lead is the most usual base for oil paint and has a very high covering capacity. It is, however, injurious to those who use it, and is very liable to be discoloured by many chemical gases, such as sulphuretted hydrogen. It should be old and not freshly made, or the paint soon loses its whiteness, but it must be protected from the air till use. It is extremely liable to adulteration, and can be relied on as pure only if obtained from the manufacturer as *genuine dry white lead*, either in lump or in powder. The materials used for adulteration are sulphate of baryta (which is similar in appearance but heavier than white lead) and whiting, which is lighter. White lead, if pure, should weigh about 400 lb. per cubic foot, and if either adulterant is used singly adulteration is detected by the variation in weight, but if the two are combined the weight may be accurately adjusted, and only a chemical test will reveal the adulteration.

White lead is often sold mixed with sulphate of baryta, which does not cover so well when mixed with oil, and when the two are mixed in equal proportions the material is termed *Venice white*, while *Hamburg white* has 1 part of lead to 2 of baryta, and *Dutch white* has 1 part of lead to 3 of baryta.

Red lead is produced by raising *massicot*, or oxide of lead, to a high temperature, during which process it absorbs oxygen and becomes converted into red lead, also known as *minium*. This material is durable if used pure and alone and not exposed to the action of acids or impure air. It is obtainable in the form of a powder and is sometimes adulterated with brickdust. Red lead is sometimes used as a drier, and it is used mixed with white lead and oil for the first coat of paint, termed *priming*, in joinery, and for the first two coats on ironwork.

Antimony vermilion, a sulphide of antimony, is sometimes used in place of red lead; it is obtained in a fine powder and is of a brilliant colour when ground in oil, and is not affected like red lead by impure air or acids.

Zinc oxide is frequently used as a base for paints; it is not poisonous like white lead, and is not liable to be discoloured by chemical fumes. When ground in oil it requires much more oil than white lead, and will require less to thin it. If it is used to give a white finish it should be mixed with refined linseed oil to secure a perfectly white surface, but this is not necessary with darker tints.

Colouring Pigments. The *colouring pigments* are much more numerous than the bases;

lists of the most usual pigments may be consulted in Seddon's "Builders' Work," under Painter, or in Rivington's "Notes," Vol. III.—Materials. These lists supply information not only as to the colour of the various pigments, but as to their nature and properties, and form a good guide as to those which may safely be used under varying conditions, and as to others which cannot be relied upon as permanent, especially if subjected to certain influences.

Mixing Paints. The proportions of the different ingredients required in mixing up paints for use necessarily vary under changing circumstances, and in particular with the nature of the material to which they are to be applied. Iron, wood, and plaster, for example, will require the paint that is to be applied to them, and in particular the first two coats, to be differently prepared, the more absorbent material requiring the use of a higher proportion of oil. The colour effect required to be produced necessarily affects the selection and the amount of colouring pigment to be added; where very delicate light tints are to be used this may affect the selection of the class of oil to be employed. The question of whether the paint is to be used for internal or external work has an important bearing on the question; in the latter case boiled oil is generally selected, on account of its superior weathering qualities. Turps is included in most paints as a thinner, its object being to reduce the consistency of the paint at the time it is applied, but it eventually evaporates and does not form a permanent ingredient.

Variation in Successive Coats. In painting any piece of work the ingredients will vary in successive coats. On any porous substance the first coat in particular must have a liberal supply of oil, which tends to sink into the pores of the material and dry there. Subsequent coats will require a certain amount of turps to make them work freely, and in painting on old work the first new coat is always mixed with a liberal amount of turps, which makes it adhere to the older work. The colouring pigments are usually mixed in with the two final coats, the last one of all being relied upon to produce the exact tint required, though the one immediately before has an important influence often on the final appearance.

Apart from any other consideration, the knowledge and skill of the individual painter always is an element in the mixing of paints; these have to be acquired by experiment and practice, which, when attained, are better than any hard and fast rules as to the proportions of ingredients.

Method of Mixing Lead Paints. If the pigment is in the form of powder it is ground up with raw linseed oil with the muller on the grindstone, and is reduced to the consistency of a thick paste, but in many cases it is purchased in this condition; if only a small quantity is required, as in the case of a colouring pigment, the paste is worked up by means of a palette knife on a slab, with the addition of a little oil and turps; but when a considerable amount is to be mixed, a painter's pot is used. The pot is first rinsed round with a little oil to prevent the white lead adhering, and then the latter is placed in it, and oil and turps added by degrees, and the lead well worked round with a stick, which may be shaped something like an oar, till the lumps are all reduced and the consistency of the whole is smooth and uniform, the palette knife being used in this operation.

If the paint is to be coloured, the colouring pigment, also ground in oil, may be added to the white lead and worked up with it if the exact proportion required is known; but it is usually better to thin it, and work it up separately, and add it to the white paint in the pot a little at a time till the exact tint or tone required is arrived at.

Adding Driers and Straining. The driers are added to the paint at this stage, and here again exact proportions cannot be given, as these vary with the nature of the drier and other circumstances; but the proportion is always small, and if a good drier is used, about 2 per cent. by weight should suffice. The rules as to the use of driers already given must be borne in mind, and in the case of a priming coat to which red lead is added, any other drier may often be omitted.

Straining the Paint. The last process in the way of preparation consists in carefully straining the paint. If this is not done, small specks and impurities are likely to be left in it, and good work will be impossible. In some cases it is useful to strain the paint two or three times. The strainer already described is made use of, the paint is poured into it, and allowed to drain out into a clean paint-pot, and it may be stirred with a stick or brush or palette knife to help its passage through the sieve, which must be carefully cleaned after the operation so as to be ready for future use.

Seddon's "Builders' Work" gives the following table of the approximate quantities of materials required for painting four-coat work to finish white and the superficial area covered by each.

Priming Coat. 10 lb. genuine white lead, 1 oz. red lead, 2 oz. litharge; or 1½ oz. litharge, ½ oz. burnt white vitriol, and 4 pints raw linseed oil. Will cover about 63 yd., varying with the absorbent properties of the surface.

Second Coat. 10 lb. genuine white lead, 2 oz. litharge, 2½ pints raw linseed oil, and 1½ pints turps. Will cover 100 super. yards.

Third and Fourth Coats. 10 lb. genuine white lead, 2 oz. litharge; or 1½ oz. litharge, ½ oz. burnt white vitriol, 2 pints raw linseed oil, and 2 pints turps. Will cover 113 super. yards.

Flatting Coat. 10 lb. genuine white lead and 4 pints turps. Will cover 150 superficial yards. To give a very pure white, ½ oz. ultramarine may be mixed with the last coat, and for coloured paint 1 to 2 oz. of colouring pigment with each of the last two coats.

Special Forms of Paint. A large number of specially-prepared paints are now manufactured by different firms, and supplied ready for use, or requiring merely the addition of some thinning material in accordance with instructions issued by the manufacturers. It is impossible to describe or even give a full list of such paints, but many of them are designed for work in special situations, and they include various forms of enamel paints. In all cases it is necessary carefully to follow the instructions issued by the makers, and in most cases several colours can be obtained in most of the different brands.

Applying Paint. The paint is transferred from the pot and applied to the surface by means of paint-brushes. For plain surfaces a *ground brush* of suitable size is dipped into the paint, taking up a moderate amount, and any superfluous paint is wiped off against the sides of the pot. The brush is held at right angles to the face of the work, so that the ends of the hairs force the paint well into the pores, and the brush must be applied vigorously. Work is usually begun at the top, and brought down, and in painting panelled

work, such as doors, the frames are usually first dealt with, then the panels. When paint is applied to the edges of any object, such as a door, in order to avoid an excess of paint at such points the brush is drawn a little away from the edges in working. Mouldings are particularly liable to collect excess of paint, and for such work it is used somewhat sparingly. When two or more colours have to be used it is necessary to take care that the edges of the colour last applied are very carefully cut in a true straight line to avoid irregularities; so also where painted work has to be finished against some other substance, as, for example, when sash-bars in a window are painted it is a sign of poor workmanship if the glass itself is smeared with paint where it adjoins the bars.

Preparing Surfaces. Before applying paint to any surface it is necessary to see that it is perfectly clean and free from grease, otherwise the paint will not adhere. It is desirable in the case of woodwork that the wood should be dry, for any moisture will be imprisoned by the coat of paint, and will not be able to dry out later. In the case of resinous woods any knots showing on a surface to be painted must be dealt with, or they will be liable to exude turpentine, and damage the work, and this process is described as *knotting*. Knots may be killed by painting with hot lime, and, when this is dry, ironing them with a hot iron and finally rubbing them smooth with pumice-stone; or the lime may be scraped off after twenty-four hours, and the knots painted with a mixture of red and white lead and linseed oil; and when this is dry the pumice-stone must be applied. It is a quicker and more usual process to cover the knots with a material termed *knotting*. This is usually *patent knotting*, a mixture of shellac and naphtha, which dries in a few minutes, leaving a protecting skin. *Red lead knotting* is also used, and is made by grinding red lead in water and mixing it with strong glue. This is applied hot, and dries in a few minutes. If, in spite of such treatment, knots still show through after the third coat is applied, they may be covered with gold or silver leaf, fixed on with size.

Priming. *Priming* is the first coat of paint applied. For woodwork it is usually formed of white and red lead mixed with raw linseed oil. A little litharge ground in turps may be added as a drier. This coat is intended to sink well into the pores of the wood and to fill them up, while at the same time the red lead hardens and forms a surface for the succeeding coat.

Clearcolle is sometimes used, but does not enter the pores, and may peel off; it should only be used for internal work, and then only if the surface has become greasy or dirty, and will not take the ordinary priming.

Stopping. *Stopping* is done with *putty*, which should be made from dry whiting kneaded up with raw linseed oil, and with the addition of a little white lead. It is applied with the stopping-knife to fill any holes in the wood. The stopping hardens in the holes, and forms an even surface for painting. In the case of coloured woods to be varnished or polished the stopping may be tinted to match the wood. Stopping should be done after priming, or the oil in the stopping will be sucked out of it by the wood.

Subsequent Coats. If the work is to be finished white or a light tint, all subsequent coats must be kept light, or they will not be fully covered by the final coat; but if the finish is to be dark the earlier coats may also be dark, and are usually of a different tint to the final coats. The reason for this is that if all the coats were of the same colour parts of the work might be easily overlooked in applying one of the coats.

The priming coat is well rubbed down with sandpaper, glasspaper, or pumice-stone before the next coat is applied, and each subsequent coat, when it is dry, is examined, and any irregularities rubbed down.

Flatting. When it is desired entirely to avoid a glossy surface in the finishing coat—and this is often a desideratum—the previous coat is mixed with a larger proportion of oil than it would ordinarily have, and the final coat is mixed with turps only. It should be applied before the previous coat is quite hard, and dries without any gloss. Such a coat will not stand washing like a coat mixed with oil, and to overcome this a little size or raw oil that has been bleached is added, and this is termed *bastard flatting*.

Graining and Varnishing. This method of finishing paint is much less used than formerly. It is more expensive to execute, but, if well done, it will wear for many years if carefully treated and given a coat of varnish from time to time. The reason for its disuse is mainly an æsthetic one—namely, that it is confessedly a sham, and that it is more artistic to treat work that is covered with paint frankly as a painted surface, and not to attempt to make it resemble a costly wood. This method, however, for office work and for the offices of good houses, is so durable and useful that it is never likely to be abandoned entirely. For work that is to be grained the priming and two or three colouring coats are laid on as usual, and the ground is then prepared of the general colour of the wood to be imitated, and this is allowed to dry. The painter then mixes in a palette colours similar to the darker grains of the wood, and these are laid over the ground, and, while still wet, painters' combs [16] are drawn over it to give the effect of graining. For fine work camel-hair pencils may be used, and the effect of knots is produced by using sponges or pieces of cloth. This work requires considerable skill and practice if the graining of highly ornamental woods, such as maple and walnut, is to be faithfully represented, but a common class of graining can be executed without much difficulty.

Overgraining consists of applying a thin extra coat of raw umber or vandyke brown, mixed with small beer, over the ordinary graining. This is applied with a large flat brush with a wavy motion, and is intended to represent the effect of silver grain.

The varnish is applied after the graining is dry, and should consist of two coats of copal varnish.

Painting Iron. The surface of the iron must be clean and free from rust, and it is often usual to paint iron with one coat directly it leaves the forge or cast. It is customary to employ red lead or an oxide of iron paint. Ironwork should have another coat of paint before fixing, and, where exposed, a total of four coats. In painting rain-water gutters and heads, both the inside and the outside must be painted. In the case of ironwork that has been dipped in Dr. Angus Smith's solution, a coat of knotting is required before painting.

Repainting Old Work. Old work requires to be thoroughly cleaned before repainting; it must be well washed with soap and water, and afterwards rinsed with clean water, and rubbed down with pumice. The first coat of new paint should be mixed with a liberal supply of turps. If the old paint is worn in places so as to expose the joinery, it must have additional coats of paint over such parts; these are first executed and

allowed to dry, and the final coats carried over the whole uniformly. Where joinery has been repaired with new woodwork, this must be treated as new joinery—primed, stopped, and two coats of paint applied. This is described as *bringing forward*, and the final coats are taken over old and new work alike. If old paint has perished or become blistered so that it is impossible to make a good job by painting over it, it must be removed ; on iron this is done by scraping, and on woodwork by burning off, a jet of gas or the painter's torch being used against the paint, which is thus softened and easily scraped off. A solution of equal parts of soda and quicklime may also be used ; the soda is dissolved in water, the lime added, and used hot with a brush, after which the paint can be washed off with hot water. If this is used the wood should be washed over with vinegar before repainting to kill the lime.

Varnish. *Varnish* is a transparent material which may be applied to natural surfaces or to surfaces already painted. Varnishes are solutions of resins or gums dissolved in spirits or in oil. Resin is the residue obtained by distilling turpentine. There are several varieties of resins, and some of them are termed *gums*. These are exudations from trees, and are, when first produced, mixed with some essential oil, which, evaporating, leaves a hard substance.

The principal resins in use for varnishes are as follow. *Amber*, obtained from Prussia, very hard and durable, but difficult to dissolve, expensive, and a slow drier. *Copal*, obtained from the East and West Indies and America, may be obtained in three different qualities, depending on the colour, the lightest being very pale, and used for high-class work. *Mastic* is a resinous gum obtained from the countries bordering on the Mediterranean. *Gum Dammar* is obtained from the kauri pine, is rather soft, and almost colourless. *Lac* is a resinous substance obtained from the East Indies ; from the natural substance *shellac* is manufactured, which is very pure, and is used in making lacquers. *Sandarach* is a somewhat similar substance, obtained from the juniper. *Common resin* is either brown, which is formed by distilling the turpentine of spruce fir in water, or white, which is distilled from Bordeaux turpentine.

The *solvents* (which correspond to the vehicles in paint) are *boiling linseed oil* used with the hardest resins and gums. Varnishes made with oil are the hardest and most durable, but take longer to dry ; they are used for superior work, and should be employed for external work. *Turpentine* is used with softer gum such as mastic, dammar, and common resin. These varnishes are less costly, and dry quickly, but are not so durable as oil varnishes.

Methylated spirit is used with lac and sandarach. These spirit varnishes are known as *lacquers*, dry quickly, and become hard and brilliant, but are apt to crack and peel, and are used mostly for cabinet work not exposed to weather.

Water is used hot with lac and with as much ammonia, borax, potash or soda as will dissolve the lac. This is inferior to the other varnishes. *Driers* are used with varnishes, and accelerate the drying, but if used in large proportions injure the durability. The usual driers are *litharge*, *sugar of lead*, or *white copperas*.

Work of a porous nature such as wallpaper or wood must be sized before varnishing, and no second coat of varnish should be applied till the coat below is thoroughly hard, or the drying of the lower coat will be stopped.

Staining. Stains are applied to light-coloured woods that are to be varnished. In some cases the colouring matter is mixed with the varnish, but it is usual to stain the wood with a liquid water-stain, then to size twice, and in good work to varnish the surface twice. In the case of floors, the margins of which are often so treated, the varnish is very apt to wear, and instead of varnishing, the work may be wax polished. The polishing is done with beeswax shredded, mixed with turpentine, and gently heated ; the wax is applied with a rag and then vigorously rubbed with a cloth or, if a large area is dealt with, by a floor polisher. This work must be kept in good order by rubbing over about once a week, and maintains a better surface than varnished work, but demands more attention. The stains are supplied in various colours, to imitate different classes of wood, such as rosewood, walnut, oak, mahogany, etc., and also in other colours, such as green ; they may be obtained in a liquid state ready for use, or in powder, which is dissolved in hot water for use ; it is laid on with a brush or sponge in one or two coats, according to the colour required, and allowed to dry before sizing.

Applying Varnish. Care and judgment are required in varnishing ; the material is sensitive to atmospheric effects and should not be applied when there is much humidity in the atmosphere ; newly varnished work must be protected from cold draughts. The varnish, until used, must be stored in a warm place and not become chilled ; varnish should not be mixed with any other kind of varnish nor thinned with oil. The varnish is applied with a varnish brush, and is usually applied across the work and finished by stroking the work down with the brush in a vertical direction to make it flow and obliterate brush marks. Care must be taken not to apply too much varnish, especially at the angles, or it will run and form tears.

Whitewashing. This term is properly applied to the whitening of internal walls and ceilings with a mixture of whiting and water mixed with size, but is also sometimes used for the covering of walls with a mixture of lime and water, which is more properly described as *lime-washing*. Lime-white and common distemper are often applied by the plasterer, but will be described here. *Lime-white* is made from pure chalk lime mixed with water. Factories and other buildings are required to be lime-whitened at regular intervals, and the material for this purpose should be applied hot. The lime is first slaked, and, when slaking is complete enough, hot water is added to dissolve the lime ; 1 lb. of pure tallow may be added to each bushel of lime or 4 lb. of sulphate of zinc and 2 lb. of common salt. Lime-whiting is also applied to the walls of cellars and similar offices. It is cheap, but will not withstand wet, and is liable to rub off, but is serviceable when it is desirable to renew a coat at short intervals of time.

Whitewash is made with *whiting*, which is white chalk finely powdered, and is sold in the form of balls. The balls are roughly broken, soaked in water, and stirred and broken up with a stick, or by hand, and left just covered with water for about six hours ; afterwards double size in the proportion of 1 quart of double size to 6 lb. of whiting is added and the mixture left to stand in a cool place till it becomes a jelly ; then it is diluted and used. One pound of jelly will cover about six superficial yards.

Size. *Size* is liquid glue prepared by boiling down the horns and sinews of animals ; *double size* is the same material, but boiled down to about half the bulk, and is therefore stronger ; both these forms require soaking before use. *Patent size* is a

preparation of gelatine, and can be used without soaking.

Clearcolle is a coat of size mixed with water, which is laid over plaster walls and ceilings before whiting or distemper.

In mixing whiting for ceiling work some colour is mixed with it to counteract the yellow effect of pure whiting. This is termed *breaking down*—a little ultramarine or indigo, or sometimes black, if a dead white is required, but with tinted walls a warmer tone may be preferred for the ceiling, and a cream colour may be formed by adding ochre.

Distemper is formed of whiting and size with the addition of colouring material to produce any desired tint; the pigments are the same as used for oil paints, and are mixed with the whiting before the size is added. All distempers appear much darker when wet than dry. The real tint of any colour as mixed should be judged by applying some of it to a piece of white paper, and drying it artificially.

Washable distempers are specially prepared and sold in the form of paste; they require diluting with water before use, and must be mixed in accordance with the instructions given by the manufacturers. They may be obtained in a great variety of tints and colours, and form a good solid surface, which will stand washing.

Applying Whitewash or Distemper. This is done with a large brush [13] with a long wooden handle. The brush is dipped well into the pail of whitewash, and any superfluous material squeezed off against the edge; the brush is then applied smoothly and evenly to the work. The distemper should be stirred from time to time with a stick, and work should not be gone over twice.

Stencilling. Very good effects may be produced by stencilling a design on a plain coloured surface to form a border or line or to cover the surface generally. The pattern is cut out of a thin plate which is also provided with guides to indicate exactly the position it must occupy when shifted. Stencils may be comparatively simple or elaborate. Sufficient substance must be left in cutting the stencil to keep all parts of it connected together, and these ties should form an element in a good design. The stencil is placed against the finished surface of the wall, and a stencil brush [14] is dipped into the colour, which is darker than the ground, and is dabbed gently and evenly over the whole stencil. It must be held at right angles to the surface or the colour may run under the stencil plate and spoil the design. A design thus produced forms an excellent frieze to a plain distempered wall.

Tar and Pitch. Tar is obtained by the slow combustion of resinous woods, and such tar is known as *Stockholm tar*, as it was formerly almost exclusively imported from Sweden; it is thinner than coal-tar and of a rich brown colour, and penetrates well into the pores of the wood.

Coal-tar is a by-product of gas-making, and is formed by the distillation of coal; it is quite black in appearance and thick.

Pitch is the solid residue obtained by distilling tar; the process varies somewhat according to the nature of the wood from which it is obtained. Pitch may be added to coal-tar in the proportion of from 1 to 2 lb. to each gallon of tar. The object is to prevent the tar from running under hot sunshine, and, if used pure, it is apt to do so; a little lime is sometimes added with the same object. Pitch may also be added to Stockholm tar, but will destroy the bright, clear colour and make it nearly black, which is a serious objection if used for ornamental timbering in half-timbered gables and similar situations. Tar is applied hot, with a long-handled brush, and is principally used for timber work, especially fences and out-buildings much exposed to the weather, but is sometimes applied to exposed walls to render them waterproof.

Tar is also applied sometimes to rough ironwork, and forms a durable covering. Two coats should be used, and a little lime or sand may be mixed with it, and worked on with a hard brush.

Tar paint is used for some iron structures, such as bridges; the best mixture is said to be ½ lb. sulphate of lime, 1 gallon coal-tar, and sufficient naphtha to make it work freely.

GLAZING

The work of the glazier consists in cutting glass to fit openings of various sizes and shapes and in fixing it into frames of wood or iron, and sometimes into openings of brick, stone, or terra-cotta, and the making up of designs in small pieces of shaped glass termed *lead lights* and fixing them, and of similar work.

The glazier's tools consist of a *diamond* [28], which is used for cutting glass. This is a small uncut diamond set in lead and mounted in a brass ferrule with a hardwood handle. *Compasses* provided with a socket on one leg into which the handle of the diamond can be fitted for cutting circular work. *Hacking-out knife* [29], often a broken table knife, sharpened on the edge, and used for cutting out old putty in reglazing.

These are the principal special tools: but several others are used, already described in other trades —*square, straightedge, rule, claw hammer* (for sprigging), *stopping knife* (for stopping-in and smoothing off putty), *dusting brush, sash tool* (for priming sashes, painting putties, etc.), and, in lead glazing, *copper bits* or *soldering irons*.

Composition and Forms of Glass. The ordinary glass used by the glazier is composed of a mixture of pure sand, soda and chalk, and broken glass; these materials are melted at a high temperature and by various processes, and are then formed into sheets of convenient size and thickness for glazing purposes.

In all forms of glass large sheets are charged at a higher price per superficial foot than small ones, as the latter can often be cut from waste or breakages. Any glass that is required to be bent is charged at a special rate if bent in one direction, and a further charge is made if bending in two directions is required.

The principal qualities of glass in ordinary use are *crown, sheet glass*, and *plate glass*, which differ from each other to some extent in composition, but mainly in the method of their manufacture.

The maximum size of a sheet of *crown glass* does not exceed five superficial feet, and the thickness varies somewhat. The weight is about 13 oz. to 1-16 in. of thickness, and, for window glazing, should be about 16 oz. per foot. The glass is sold either in crates of tables containing half table, semicircular in form, or in crates of slabs cut to sizes. This glass is very clear and white, but the surface is considerably curved unless specially flattened, which makes glazing difficult, and it can be used only for frames of a small size. There are several qualities—*selected qualities*, for glazing pictures, of which A is the best and B the second; ordinary glazing qualities, divided into *bests, seconds, thirds*, and *coarse*.

Sheet glass has to a great extent superseded crown glass for most purposes. The surface may be polished or ground, and the glass bent to curves

if required. This glass is made quite clear, known as *crystal* or slightly tinted; it is to be had in the same qualities both for pictures and glazing as crown glass; it is usually described by its weight per superficial foot; the usual weights and thicknesses are as follow: 15 oz. = 1-15 in.; 21 oz. = 1-10 in.; 26 oz. = 1-9 in.; 32 oz. = 1-7 in.; 36 oz. = $\frac{1}{6}$ in.; 42 oz. = $\frac{1}{5}$ in.

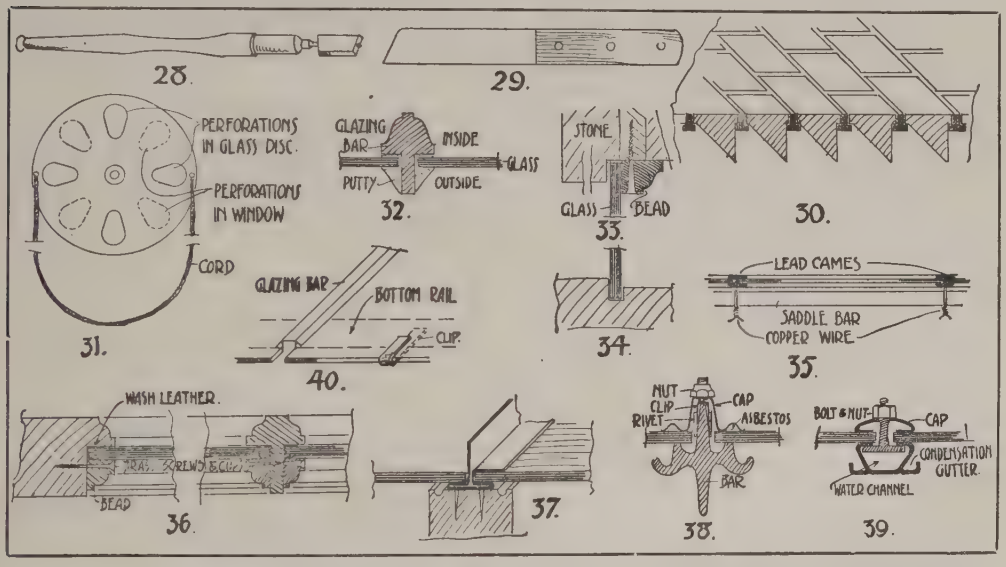
This glass is not quite so clear or white as crown glass, but it can be obtained in much larger panes, because the sheets, being rectangular and having no bullion, can be cut with much less waste. In all glass some small air-bubbles are formed; in sheet glass, and in the forms of plate glass prepared from it, these small bubbles have an oval or elongated appearance, the result of the process of manufacture, whereas, in cast plate, hereafter to be described, the bubbles are perfectly globular.

Plate Glass. *Patent plate* glass, or *blown plate*, is produced by polishing sheet glass on both sides, and is generally formed of the thicker qualities. It is obtainable in two colours, ordinary *crystal* and *extra white*, and the qualities are known as *best*, "B," *second* or "C," and *third*, or "C.C."

Rough cast plate is the commonest form of plate, and can be obtained in sheets of large size; its thickness varies from $\frac{1}{4}$ in. to 1 in., and it is very strong, but the surface is somewhat wavy. It is used for forming the risers of steps, and for glazing windows near the ground level where protection is essential, and for pavement lights. It is the cheapest form of plate, and is made in one quality only.

Rough rolled plate was patented by Messrs. Hartley & Co., and is often known as Hartley's rolled plate. For this glass the iron table on which it is rolled has the surface covered with the fine lines or flutes formed on the surface, and these are impressed upon the glass when it is rolled out; the rollers are smooth, and one side only of the glass is thus fluted, but the other side is somewhat wavy. Glass can be obtained up to 10 ft. long and 3 ft. wide in this form, and it is rolled in the following thicknesses: $\frac{1}{8}$ in., weighing about 32 oz. per square ft.; 3-16 in., $\frac{1}{4}$ in., $\frac{3}{8}$ in. This glass is much used for skylights, conservatories, and in windows of factories, etc. Light admitted through it is somewhat diffused, and the glare of sunlight is diminished, but more light is obstructed by this quality of glass than by polished glass. In fixing, the smooth face is usually placed outside.

British polished plate is cast in the same way as rough cast plate, but a superior quality of glass is cast for polishing, and it is afterwards ground down to an even surface and then polished on both faces. This glass is prepared in several qualities—*silvering quality*, specially intended for mirrors, but used also for the highest quality of glazing; *best glazing*, and *ordinary glazing*. This glass can be obtained in sheets of immense size, though very large sheets are charged at a special rate but sheets up to 100 ft. area are usually kept in stock in several thicknesses. This glass is very clear and colourless, it transmits a greater proportion of light than any other material, and, in common with all forms of plate, is very strong; if $\frac{1}{4}$ in. thick, it prevents cold from penetrating to a great extent.



GLAZING TOOLS AND SYSTEMS OF GLAZING

28. Glazier's diamond **29.** Hacking-out knife **30.** Prismatic glass **31.** Glass ventilator **32.** Glazing with putty **33.** Glazing in stone jamb **34.** Glazing in terra-cotta jamb **35.** Lead glazing with saddle-bar **36.** Glazing with wood beads. **37.** "Simplex" glazing **38.** Helliwell's glazing **39.** Rendel's glazing **40.** Glazing skylight

Figured Rolled Glass. There are various other methods of treating glass surfaces by rollers, which are of more recent introduction. But in all cases the method of production is somewhat similar. Of these forms of glass, one of the best known is *Muranese*, which is entirely covered on one face with small flutes, not parallel, but arranged somewhat after the pattern of a shell, in various shapes. This may be obtained in white or tinted glass. Another similar glass is known as *Arabesque*, and this also is formed with radiating grooves. Other forms are rolled, which are foliated in character, such as the *Japanese* pattern, in which flowers and foliage are represented on a ground covered with dots in place of grooves, and the *Flannel Flower*

pattern, which differs in design, but resembles the Japanese in treatment. The object of all these forms of glazing is to destroy the transparency of the glass with as little damage as possible to its translucence.

Wired Glass. This is ordinary glass, but has imbedded in its thickness a layer of wire netting. The glass surface may be treated either as cast or rolled or polished. The special advantage of the wire is that, in the event of the glass being broken by accident or by fire, the fragments are bound together by the netting, and will not fall out. It further increases the resistance of such glass to the attacks of burglars. The wirework is, of course, visible, especially in the polished glass, and this may make it undesirable to use for such positions as shop fronts, but for skylights, and in other positions in which the presence of the wire is not objectionable, it is very serviceable. It may be obtained in lengths up to 100 in., and up to 36 in. broad.

Glass ventilators are sometimes used; these may either be cast with perforations in them or the perforations may be cut afterwards. This is the most satisfactory plan, as such a ventilator can be cut where desired in a large plate; a circular disc of glass, with similar perforations, may be fixed over it so that it will rotate on its axis and form a hit-and-miss ventilator [**31**].

Cut Glass. Plate glass may be ornamented by cutting the surface so as to form a floral or foliated design. This cutting includes bevelling the edge, which is sometimes introduced and is effective, and also ornamental lettering. The surface is cut by means of an emery wheel, and afterwards polished. The wheel revolves on a stationary bed, and the glass must be brought into contact with it whenever any cutting is required. In order to do this, the sheet of glass is mounted in a frame and balanced with a counterpoise; it is then moved by the workman so that the cut is made of the desired size and shape. The cost of cutting is higher for the same amount of work on a large pane than on a small one, owing to the increased difficulty of manipulation.

French embossing is also executed on plate glass; in this work, the surface of the glass, excepting those portions which are to be embossed, is covered with Brunswick black; the surface is then subjected to the action of fluoric acid, which eats away the unprotected surface, giving it a dull, slightly opaque effect. The action of the acid may be stopped in certain parts of the design at any time by painting them out, and in this way some portions are more deeply eaten than others, affording a further contrast with the plain glass. The effect may be still further heightened by combining embossing and brilliant cutting in the same piece of glass.

Transparency of Glass. Even the most transparent glass will not allow all the rays of light that reach the external surface to pass through it, but some kinds of glass obscure or reflect much more light than others. The diminution of light caused by filling an opening with different qualities of glass, as compared with the same opening unglazed, is as follows: Of the total light received, British polished plate, $\frac{1}{4}$ in. thick, intercepts 13 per cent.; sheet glass, 32 oz. to the foot, intercepts 22 per cent.; rough cast plate intercepts 30 per cent.; rolled plate, four flutes to an inch, intercepts 53 per cent.

Glass is prepared in the special forms of *prisms* for certain glazing work; these are cast of the required form, and afterwards polished and made up into lights for use as pavement lights, stall boards, coal plates, etc. [**30**]. The manufacture of these lights is in the hands of special makers, and they are usually supplied complete in their frames, which in some cases, on account of their weight, are hinged and balanced with counterweights, if they are likely to be frequently opened. The object of all such prismatic glass is to deflect the rays of light reaching the inner face of the glass and to send the rays in a horizontal direction, or nearly so; by this means the back portion of rooms that would otherwise be very badly lighted may receive a greatly improved illumination.

Glazing with Putty. For most glazing fixed in wood or iron frames, *putty* is used for fixing the glass to the frame. *Glaziers' putty* is made of whiting mixed with linseed oil and well kneaded; sometimes a little tallow or non-drying oil is added to it to keep it slightly soft, so that it shall not be damaged by the alternate expansion and contraction of the glass. When used, the putty is in a plastic condition, but somewhat stiff; the frame should have been at least primed; and if this has not been done, the rebate that receives the glass must be painted, or the wood will soak up the oil in the putty before it had hardened. The glass is cut so as to fit somewhat loosely in the frame that is to receive it. If it were tight at any point, there would be a risk that the glass would split under the effect of expansion and contraction—if any slight settlement in the building should tend to alter the shape of the frame the same accident might occur—whereas, if it is slightly smaller than the frame, the conditions suggested should produce no such result. The edges of plate glass should be blackened before glazing, to prevent the effect of reflection from them.

Puttying. The first operation is to draw or spread a thin layer of putty fairly evenly along the back of the rebate all round the frame; this is not carefully smoothed, but left from the knife that is used to spread the putty. The sheet of glass is placed in the frame and pressed firmly against the putty on the rebate, which thus becomes reduced to a uniform thickness, and some putty is generally squeezed out in the process and will stand above the wood of the sash all round on the inside of the glass. This is not at once removed, but left till it gets hard, and is then cut off, generally after an interval of about a week.

If the sheet of glass is large and heavy, it is very often *sprigged*. This consists in driving small brads of iron or brass into the woodwork at intervals, to hold the glass in position till the putty has hardened and is firm enough to hold the glass securely. But with panes of ordinary size this process may be, as a rule, omitted. When the glass is in position, additional putty is worked on all round the panes on the outside, and finished with a sloping or weathered surface [**32**]. The external surface of the putty should be painted at once, to prevent its drying too rapidly and cracking. A sash tool [**11**] is used, and care must be taken to see that the paint is not smeared on the glass.

Putty Glazing to Skylights. When putty is used for glazing skylights, the system is similar. It is desirable, when possible, to employ a single sheet of glass to glaze each division of the light. The lower edge, or *tail*, is often supported by a copper clip [**40**] to give it additional security; and if two or more sheets of glass are used, they must be well lapped, and a copper clip may be used to support the upper piece. The extent of lapping will depend on the slope, but is usually about

1½ in. The lower edge of the glass runs over the apron of the light, and should be allowed to cover it completely; but in some cases it is stopped on the back of the apron, with the result that water is delivered on to the surface of the apron, and, especially if the inclination of the light is not great, this is liable to rot the wood. In glazing greenhouses and garden-lights, the glass used is generally thin, and is used in small pieces, with several horizontal joints and a small lap. In such work the metal clips above referred to are not required. If ground glass is to be fixed with putty, the surface round the edges should first be sized to prevent the putty from discolouring it.

Glazing in Stone and Terra-cotta. In certain styles of buildings sheets of glass which are not required to open may be fixed in the stone or terra-cotta opening without the use of any wood or metal frame. This is usually done by forming a rebate in the frame, fixing the glass against the rebate, and securing it in position with hardwood beads or mouldings screwed to wood or lead plugs let into the jambs [**33**]. The outer edge between the glass and the rebate is pointed all round in cement.

Where the glass does not consist of a single sheet, but is in the form of a leaded light, a groove is formed instead of a rebate in the material of the window opening, and the glass-light can be slightly bent, placed in the groove, and afterwards straightened out and fixed and pointed in cement [**34**].

Saddle bars are usually required for assisting to support lead lights which, in windows of any size, are not rigid enough to resist any considerable wind pressure. In the simplest form the saddle bar is a square bar of iron from ⅜ in. square upwards, depending on the strength required. The ends are fixed to the frame into which the light is fixed, and the light is secured to the saddle bars with copper wire [**35**]. If the jambs of the opening are of stone or terra-cotta, a mortise is cut in each side for the saddle bar, and it is run in with cement. If a wood frame is used, the ends of the bar may be turned up and flattened and perforated for a screw and then fixed to the frame.

Glazing Internal Lights. Where glass is to be fixed in an internal screen or door, putty may still be used; but in such cases, when there is no exposure to the weather, it is not essential—and it is often preferred—that both sides of a frame should have the same character and appearance. In such cases the glass may be secured in the rebate by means of small wood beads or mouldings fixed to the frame and glazing bars with small screws [**36**]. These should be of brass, and brass cups are usually provided and let into the beads to take the heads of the screws exactly. Such an arrangement allows of easy and quick repair to any pane that has been broken, by merely removing the mouldings, inserting the new pane, and refixing them. Where the upper panels of doors have to be glazed, the same system may be used, but a strip of washleather or vulcanised indiarubber is used for holding the edge of the glass, to reduce the vibration due to the opening and closing of the door, which might otherwise crack the glass.

Glazing Without Putty. The drawbacks of putty are that the material does not remain permanently sound, but is apt to perish, especially in the case of skylights in which the glass is not placed vertically, but often at a very flat angle. This decay may be greatly retarded by careful painting at least in every second year, but in time putty is apt to crack, and ceases to be watertight. Several systems have been adopted to avoid the use of any putty, and to provide for securing the glass in position by mechanical means. Such a system must be, nevertheless, watertight; must not interfere with the expansion or contraction of the glass, and at the same time must render the execution of repairs an easy and rapid operation. It is essential that the construction be strong enough to allow of workmen getting about on the roof to execute repairs. The simplest form of this class of glazing is termed the *Simplex* [**37**], and can be utilised with existing wood lights and bars by removing the rebates on the latter, or may in new work have bars specially prepared for it. The system makes use of a strip of lead specially folded so that it may be nailed to the top of the bar, and, after the glass is put into position, the edges are turned down and dressed over the glass. The lead strips are secured to the wood bars with copper nails, placed on alternate sides of the centre line 4 in. apart.

Rendle's Invincible glazing [**39**] has a specially formed bar of zinc or copper provided with condensation gutters, which is sufficiently strong for lengths under 4 ft., but for longer lengths must be carried on a bar of wood or a T-iron. The glass rests on this bar, and a metal capping is employed, secured by bolts and nuts at intervals.

Hope's glazing has a specially moulded steel bar with a dovetailed groove in the centre of the top. Into this a special cast-lead cover strip is screwed, with flanges dressed down over the glass.

Helliwell's Perfection glazing [**38**] also employs a moulded steel glazing bar, with a capping of lead, zinc, or copper fixed with brass bolts and nuts.

Leaded Lights. *Leaded lights* are formed of small pieces of glass fitted into grooved lead strips, which are soldered together to form lights or panels. The glass may be white, coloured, stained, muffled, or rolled. The lead strips, or *cames*, are of an H section and are drawn, and the joints are soldered. The cames are cut rather short, and drawn through a *compression vice*, the effect of which is to harden and polish the surface and to mill the groove. The centre between the grooves is the *heart*, and each of the sides is termed the *leaf*. This is usually flat or round, but may be beaded, and is, for ordinary glazing, from ¼ in. to ½ in. wide, but may be as much as 1 in. The two leafs are opened out to receive the glass, and then a cement is brushed under the leaf, consisting of mastic or whiting and red lead, and the leaves are then closed down on the glass and coated with blacklead, or the surface may be gilded. They should be allowed a week to harden before fixing. The cames are bent to fit the outline of irregular pieces of glass, and the various lengths of cames are soldered together where they meet. Short lengths of copper wire are also soldered in for fixing to the saddle bars already referred to. The cames often play an important part in the design of ornamental lights; and in all such work due provision for the saddle and stay bars must be made.

A more rigid method of fixing up panels from small sheets of glass has been, within recent years, introduced by the Luxfer Company. The pieces of glass are carefully cut and laid out on a table with copper ribbons till the panel is formed up of the requisite size. This is then put into an electrolytic bath, and copper is deposited between the edges of the glass, and intimately connects it with the frame, forming an extremely rigid panel.

R. ELSEY SMITH

Erecting Poles and Running the Wires. Insulators. Wire Tables. Ohm-mile Constant. Underground Pipe-laying. Cabling and Jointing.

POLE, WIRE, & UNDERGROUND WORK

Aerial Lines. Great skill and judgment have to be brought to bear on the construction of aerial telegraph and telephone lines. When a conductor suitable from the point of view of resistance and mechanical strength has been chosen, there remains the mechanical problem of supporting and insulating the conductors at a suitable height to secure freedom from interference, and with sufficient strength to meet the static stresses due to the weight of materials and the kinetic stress due to the wind pressure.

The static stress is greatest at the pole where the line begins or ends, usually called the *terminal pole*. There it is the sum of the stresses of the wires; at intermediate poles, where the line is straight, the static stresses due to the wires on each side may balance each other, and in this case the pole, together with half of the span of wires on each side of it, may be considered as analogous to the mast and sail of a ship; the wind presses on the side of the wires as on the side of the sail; and if the pole is not sufficiently strong it will snap off at the bottom, as does many a good mast. For this simplest case, then, we need to know something about wind pressure.

Wind Pressure. Wind pressure varies as the square of the velocity. A brisk wind of 20 miles an hour exerts a pressure of 1·08 lb. per square foot; a very high wind of 40 miles per hour gives 4·32 lb. per square foot; 70 miles an hour gives over 17 lb. per square foot; while a hurricane may attain a velocity of 100 miles per hour and a pressure of over 32 lb. per square foot. Standard practice has decided that lines should be built to resist a maximum pressure of 17 lb. per square foot.

Next, we must ascertain the dimensions of the resisting surface. As the wires are circular, the effective area is taken as two-thirds of the diameter into the length. A simple calculation will therefore give the horizontal stress due to wind pressure. But this is at the height of the wires. To find the moment at the ground line, we must multiply by the distance between the resultant point of the pressure—usually midway between the top and the bottom wires—and the ground line. The result is usually expressed in foot-cwts. This tells us, then, the stress which will act upon our pole at the ground line. The engineer is provided with a table in which the breaking stress in cwts. for various thicknesses of poles is recorded, and he might now obtain from this list the dimensions of a pole which would give the required strength. Where wooden poles are concerned, however, the possibility of a particular sample being much below the average has to be borne in mind, and in this case, as in all similar engineering designs, it is necessary to introduce a factor which shall make for safety, and is, indeed, always referred to as the *factor of safety*. For poles and supports this factor is taken as 8; so that, before selecting from his list, the engineer would multiply the "foot-cwts." result by 8. For poles at angle points allowance must be made for the increased static stress.

Selection of Route. The erection of a line is preceded by careful surveys, in which the relative advantages of different routes are considered, and the one is chosen which combines most of the following advantages:

Shortness, so as to reduce the cost;
Straight rather than tortuous roads;
Ease of access for building and maintenance:
And freedom from difficulties as to wayleaves.

During the progress of the detailed survey all information for the guidance of the foreman who will erect the line is carefully tabulated, positions being chosen for the poles so as to avoid causing obstruction to the public and danger from passing vehicles. They must also be chosen so that the wires shall not hang longitudinally over the carriageway, and poles should be placed so that, if the wires fall, they will fall clear of traffic. Road crossings should, as far as possible, be avoided, and on hilly roads the heights of the poles are adjusted, as far as possible, so as to avoid abrupt differences in the level of the wires.

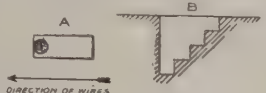
Poles. Wooden poles are used almost exclusively in this country. Wooden poles are preserved from rot by creosoting; 6 lb. of creosote per cubic foot is injected into the pole. Poles so treated have very long lives. They can now be painted, the Ruping process, recently adapted, enabling this to be done. Cresosoted poles having lengths up to 85 ft. and diameters up to 20 in. can be obtained. For light lines the poles are placed at 70 yard to 80 yard intervals, and for medium and heavy lines 66 yards is the usual interval.

Hole Digging. The hole for the pole should be dug in the direction of the wires. As little ground as possible should be disturbed. It should be arranged so that the pole will stand at one end, and this end should be cut down perpendicularly [39]. For ordinary lengths 4 ft. to 6 ft. is the usual depth, but the character of the soil must be taken into consideration. For very long poles 8 ft. to 10 ft. may be necessary, but this is the maximum. In very loose soil or running sand it is sometimes necessary to use concrete. The poles should be set so as to bear against the stress of the wires. In returning the earth to the hole, great care must be taken that the soil is thoroughly punned in, and on completion the soil of the roadway should be returned, as far as possible, to its original condition.

The height of the pole should be such that along country roads the lowest wire is not less than 12 ft. from the ground; in crossing roads and railways this must be increased to 20 ft.; in towns, 22 ft. minimum for road crossing and 28 ft. for crossing overhead trolley wires.

Iron poles are made of 11 ft. parallel lengths with 16 ft. tapering lengths, and the bottom fits into a cast-iron base, which gives a good hold in soft ground. A concrete foundation is usually provided, so that the pole may be secured by bolts let into the concrete. The parts of the pole are put together on the ground.

Stays. The strength of a line is enormously increased by a proper discrimination in providing stays at suitable points. Stays are usually made of iron wire, and they are arranged so that the upper end is attached as nearly as possible at the resultant point where all the forces acting upon the pole can be balanced by an opposing force. They are therefore specially suitable at angle points. The lower end of the stay is connected to an iron rod fitted with a stay tightener, and the farther end of this rod is passed through a wooden block, usually a 2-ft. length of old pole. The hole for the stay block is usually arranged so that the block is placed in an under-cut space and fits against the solid earth. Where it is impracticable to fix stays—as, for instance, at an angle in the road where the stay would have to be put on the road side of the pole—struts are used, and figure **40** sufficiently illustrates their application.



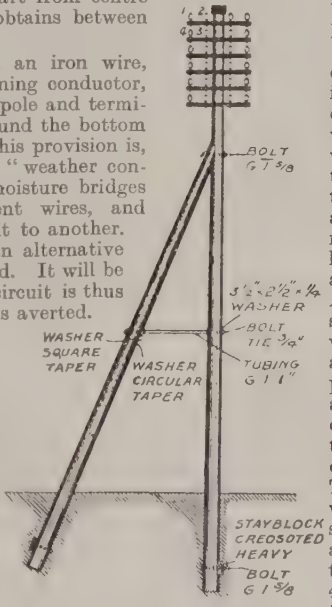
39. HOLE FOR POLE

For the heaviest class of trunk telephone lines, the Post Office has within the last few years introduced a system of trussed "H" poles. These have given splendid results and are illustrated in diagram **41**.

Pole Arms and Fittings. For arms, British oak, well seasoned, is usually employed, and sometimes kauri wood. The sections vary from 2¼ in. to 3 in. square. Arms 48 in. long carry four insulators, and lengths up to 78 in. are in common use. Arms are usually spaced 12 in. apart from centre to centre, and this distance also obtains between the respective insulators.

Poles are always provided with an iron wire, which is arranged to act as a lightning conductor, and is stapled down the side of the pole and terminated in one or two coils stapled round the bottom of the butt. The main purpose of this provision is, however, to prevent what is called "weather contact." In wet weather a film of moisture bridges the distance between the adjacent wires, and current would leak from one circuit to another. The *earth-wire* provides, however, an alternative path. The arms are also earth-wired. It will be seen that the loss of current per circuit is thus slightly increased, but interference is averted.

Pole Roof. The top of the pole is usually cut obliquely, coated with a mixture of coal-tar, creosoted and provided with a galvanised iron roof. In towns, ornamental pole-finials are used. When the fitting of the pole with roof, earth-wire, arms, and, in some cases, galvanised iron steps, has been completed, it is erected by pushing the butt into the hole, so that the butt end will come easily into the place it will finally occupy. The stepped end of the hole acts as a fulcrum in such a way that the weight of the butt assists in lifting the top, and the pole is gradually raised to the vertical position at first by hand, and subsequently by ladders, half a dozen men being usually employed. Even for the heaviest poles, ten men are quite sufficient where the foreman exhibits proper generalship. The presence of too many men is apt to be a source of danger, and a proper understanding between those concerned in the work is of the utmost importance.



40. POLE WITH STRUT

Insulators. The standard pattern insulator used in England is made of white porcelain, screwed so as to fit on a screwed steel spindle, and provided with two petticoats [42]. For short lines, where a very high standard of insulation is not necessary, brown earthenware made in the same pattern is frequently used. In fixing the insulator an india-rubber washer is inserted between it and the shoulder of the spindle to allow for differential expansion. The insulators are put into position after the pole has been erected, the steel spindles being securely bolted to the arms. It is interesting to note that in America glass insulators are used instead of porcelain, and wooden (locust) pins instead of steel spindles. At terminal poles, where the pull is all on one side, J-shaped spindles are used, fixed to the under side of the pole, and arranged so that the pull of the wire comes opposite the centre of the arm—this prevents the arm from being twisted.

Wire. Three classes of conductor are in general use—namely, iron, copper, and bronze—iron wire for unimportant telegraph circuits, copper for important telegraph and telephone circuits, and bronze wire for use in towns where irregular spans demand increased mechanical strength. Full particulars are given in the table.

Ohm-mile Constant. This should be carefully memorised. It enables the resistance per mile of any conductor, which may be named by its weight per mile, to be at once ascertained.

Thus, if 70 lb. bronze is referred to, $\frac{1820}{70} = 26$, which is the resistance in ohms per mile. See table on page 5504.

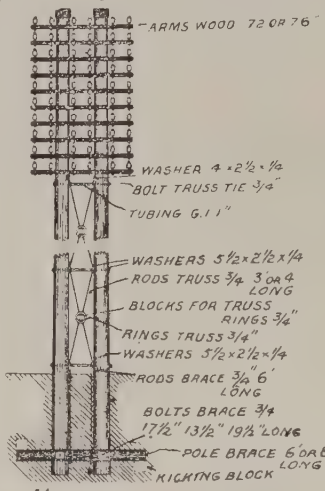
Erection of Wire. The effects of temperature have a most important bearing upon the erection of aerial wires. It is clear that, if wires are erected in hot summer weather, when winter approaches they will gradually shorten, owing to the decrease in temperature, and if sufficient allowance is not made for this it is possible that the limit of elasticity may be passed and the wires ultimately broken. Arrangements are therefore made so that the stress to which the wires are pulled up on erection is arranged with reference to the temperature in such a way that should a winter temperature of 22° F. occur, the stress will then be at the maximum allowed—namely, one-fourth of the breaking stress. This is another way of saying that wires are erected with a factor of safety of 4 for low winter temperature, and that at all other times the factor of safety is higher than 4. To secure this state of affairs, tables showing the stresses for various lengths of span corresponding to different temperatures are prepared for all classes of conductors, and supplied to the wiremen, who are also supplied with thermometers. Owing to their differing temperature co-efficients, dissimilar conductors are never erected on the same pole route if it can be avoided. For bronze, a factor of safety of 3 instead of 4 is employed.

Twisted Wires. For the purpose of eliminating inductive disturbance in metallic

telephone circuits, it is necessary to arrange the two wires which form a loop in such a way that their average distance from all disturbance is the same. This condition is attained in England by causing the wires to revolve round each other. Four wires forming two telephone circuits are taken together, and arranged so that they form a square on, say, the left side of the pole on the top two arms [40]. These are numbered as follows:

No. 1.—Top outside.
No. 2.—Top inside.
No. 3.—Bottom inside.
No. 4.—Bottom outside.

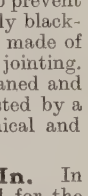
Nos. 1 and 3 form one circuit, and 2 and 4 the other circuit. At the next pole the wires from No. 1 position will shift to No. 2 position, the No. 2 wire to No. 3, and so on, and this process is continued, so that on the fifth pole the wires come back to the same position that they occupy on the first, having completed one revolution. If, now, a single-wire telegraph circuit is sending out disturbing electromagnetic waves, the inductive effect on one wire of the telephone circuit will be balanced by the equal and opposite effect of the other, and the disturbance will be completely eliminated. In American practice it is preferred to run the wires straight on the arms, introducing, however, crosses at frequent intervals on what are known as "transposition poles."


ARMS WOOD 7 2 OR 7 6'
WASHER 4 × 2½ × ½
BOLT TRUSS TIE ¾"
TUBING G.I.1"
WASHERS 5½ × 2½ × ¼
RODS TRUSS ¾ 3 OR 4 LONG
BLOCKS FOR TRUSS RINGS ¾"
RINGS TRUSS ¾"
WASHERS 5½ × 2½ × ¼
RODS BRACE ¾" 6' LONG
BOLTS BRACE ¾
17½" 13½" 19½" LONG
POLE BRACE 6 OR 8' LONG
KICKING BLOCK

41. POLE FOR HEAVY TRUNK LINES

Joints. The connections between successive lengths of iron wire are made by means of the Britannia joint. The ends of the two lengths of wire are cut off and laid side by side for about 2 in.; binding wire is then wrapped round the conductors over the whole of the over-lap portions, and with a few turns on the single conductor at each end; and 60 lb. galvanised iron is used for jointing. A flux is then applied, and the joint rapidly soldered, overheating being carefully avoided and the joint being allowed to cool naturally. In order to prevent electrolytic action, the joint is subsequently black-varnished. For copper conductors, sleeves made of flattened soft copper are employed for jointing. The ends of the wires to be jointed are cleaned and slipped into the sleeve, which is then twisted by a special tool, thus making a good mechanical and electrical joint without soldering.

Wire Running and Binding In. In order to pay out the wire uniformly, and for the purpose of avoiding kinks, a rotating drum is employed. A long length of wire is run out, sufficient for eight or ten spans, the wiremen passing it out loosely over the arms at each pole. The wires are first drawn up as tightly as possible by hand, and then by draw-tongs. A tension racket is connected to the draw-tongs for the purpose of observing the stress. When the wires have been drawn up to the proper tension they are attached to the insulator. This is done, in the case of iron wire, by using 60 lb. binding wire. This is first lapped round the line wire on one side of the insulator, then taken round the neck of the insulator and lapped round on the other side; two thicknesses of wire are usually employed. For copper wire, a different method is in vogue: the line wire is first served with a sheath of copper tape to protect it from abrasion against the insulator neck; a copper binder, about 20 in. long and having its centre of round copper and its ends flattened out, is then applied; the round part passes round the insulator neck, and the flattened ends are wrapped round the taped conductor, the wrapping being arranged over on one side and under on the other. The effects of the mechanical stresses are most violent at the point of the attachment to the insulator, and this is where breakages most usually occur.



42. INSULATOR

Maintenance of Aerial Wires. Skill and judgment are as necessary for the maintenance as for the erection of lines such as have been described, and in stormy districts the lives of the engineers and linemen are seldom troubled by monotony. As the number of wires increases, constant vigilance has to be exercised, to eliminate weak spots. The poles have to be examined periodically to see that the normal factor of safety has not been unduly encroached upon. In districts where snow prevails, accumulations sometimes take place which transform the wires into white ropes of 3 in. to 4 in. diameter, a result which is usually followed by the practical demolition of the lines, especially where frost and wind follow the accumulations. Trees are often blown by the wind across the lines, and when one span has been broken through the trouble may run back for a considerable distance, owing to the sudden removal of the balancing stresses. Spans over rivers and ravines have to be negotiated, and in all cases the work of repair has to be done against time, as communication must be restored after the briefest interval.

Underground Work. Aerial conductors have, broadly speaking, two principal advantages over the underground method of construction—namely, low cost and, owing to the small electrostatic capacity, high efficiency as electrical con-

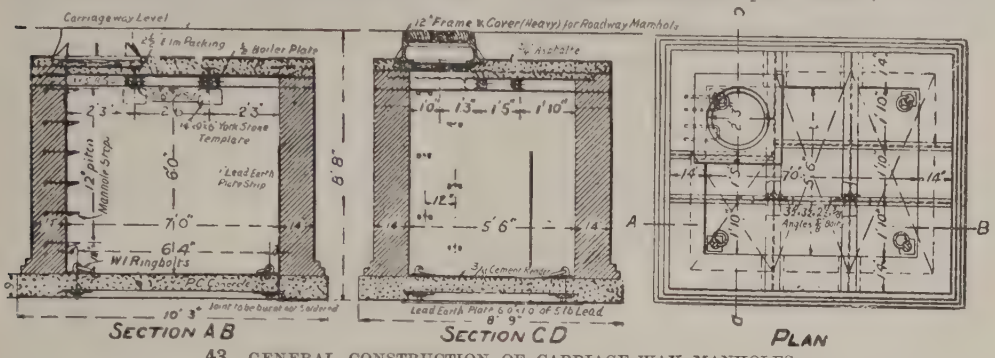
PARTICULARS OF CONDUCTORS

Weight per mile (lb.) standard	Approximate standard wire gauge	Diameter (mils) standard	Resistance in standard ohms per mile at 60° F of standard size	Minimum breaking stress (lb.)	Ohm-mile constant resistance by weight
		IRON WIRE			
400	7–1/2	171	13·32	1240	5328
200	10–1/2	121	26·64	620	
60	16	66	88·8	—	
		HARD DRAWN COPPER WIRE			
800	4–1/2	224	1·098	2400	878
600	6	194	1·464	1800	
400	8	158	2·195	1250	
300	9–1/2	137	2·928	950	
200	11–1/2	112	4·391	650	
150	13	97	5·855	490	
100	14	79	8·782	330	
*181	7/19	†(40)	4·86	580	
*112	3/18	†(48)	7·87	350	
		BRONZE WIRE			
150	13	97	12·14	730	1820
70	16	66	26·	345	
40	18	50	45·5	197	

*Strand † Diameter per strand

ductors, but these are frequently outweighed by other factors, which lead to the substitution of subterranean routes.

In large cities, overhead routes are generally unobtainable. Moreover, when some degree of conducting efficiency can be sacrificed, and where the number of conductors is large, the underground system may be found to be cheaper, especially when



43. GENERAL CONSTRUCTION OF CARRIAGE-WAY MANHOLES

the cost of subsequent maintenance is taken into account. Maintenance, which is heavy in the case of aerial wires, may, by good first construction, be reduced to insignificant dimensions in the case of underground work. Until about the end of the last century, wires insulated by a covering of gutta-percha were almost invariably used. These were placed in iron pipes of 2 in. or 3 in. diameter, with joint boxes at suitable intervals. When telephone circuits were concerned, the wires were made up in fours, twisted together to form a "quad" cable. A 2-in. pipe could take seven and a 3-in. pipe nineteen of such quad cables; and as they could not be drawn in over each other, it was necessary either to fill the pipe at one operation, or, in cases where this had not been done, to draw out one lot before pulling in another.

These G.P. wires had conductors of 40 lb. copper, insulated with 50 lb. of gutta-percha to a diameter of 174 mils (the mil is $\frac{1}{1000}$ in.), and not more than eighty wires were ever pulled into a 3-in. pipe.

Cables. The invention of the dry-core cable has, however, revolutionised affairs, and it is safe to say that the present highly developed underground telephone systems would have been impossible without it. In this form of cable the wires are wrapped in paper, but the real insulator is dry air. The electrostatic capacity is one-fourth that of gutta-percha cables. The paper-covered wires are enclosed in a tube of lead, but the economy of space is such that a 3-in. iron pipe will accommodate any of the following lead-covered cables:

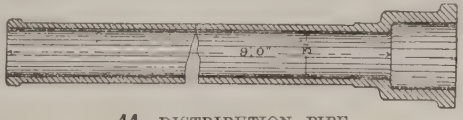
100	*pairs*	with 40 lb.	conductors
300	„	„ 20 lb.	„
800	„	„ 10 lb.	„
1000	„	„ 6½ lb.	„

as compared with the eighty gutta-percha-covered wires already mentioned.

Post Office London Underground System. It is probable that a description of the methods adopted by the Post Office in laying down their huge underground system will best enable the student to comprehend this subject. Beginning at the exchange, we have first the main conduit routes. These are laid along the centre of the main thoroughfares, and contain ducts varying from six up to any required number.

Earthenware Ducts. The ducts are made of earthenware, 18 in. and 24 in. in length, with internal circular section $3\frac{1}{4}$ in. diameter, and external hexagonal section $4\frac{1}{2}$ in. diameter. In building a duct route, the ground is first excavated, and, if necessary, shored up. A 6-in. concrete foundation is then laid, having embedded in it T-irons laid lengthwise under every alternate line of ducts. These are $2\frac{1}{2}$ in. by $2\frac{1}{2}$ in. by $\frac{1}{4}$ in. thick, and they are employed to resist the vertical displacement stress. When the concrete has set, the layers of ducts are put down, bedded in cement mortar. As in the case of succeeding lines of brickwork, the ducts are arranged so that the joints in one line do not coincide with those in adjacent lines.

To facilitate jointing, wooden mandrels are used, 11 in. long and $3\frac{1}{8}$ in. diameter. When a joint is being made, the mandrel is arranged so that one half of it is in each of the abutting ducts. A strip of prepared calico, which has been soaked in ozokerit to make it adhesive, and which is 20 in. long by $4\frac{1}{2}$ in. wide, is then wrapped tightly round the joint. The mandrel is then drawn forward. Such joints can be made rapidly, and a train of a dozen mandrels is usually employed. Of course, it is absolutely essential that the ducts shall not be deflected during the subsequent operations, and, once the cement mortar has set, the permanence of the whole system is assured. When all the ducts required are in position, concrete is added to the sides and top, and the roadway filled in and reinstated.



44. DISTRIBUTION PIPE

Multiple Way Ducts. An alternative method of providing conduits is in the form of concrete blocks, called *multiple way ducts*. These occupy less space and are cheaper, and, wherever a straight route is available, are now used in preference to the built *in situ* system which we have described above.

The blocks are made in sizes for 3, 6, 9, 12, 16, 20, 25, 30, and 36 ducts. They are all one uniform length—one metre (39·37 in.). In laying them, the joints rest on short concrete bearers bedded in the earth, and strength and proper alignment are secured by continuous lengths of square iron rods, which are inserted in recesses in the top and sides of the blocks. The iron rods are covered with cement.

Manholes. At intervals of 150 yd. to 180 yd. manholes are provided to house the joints. If possible, the junction of thoroughfares is chosen as the position. These roadway manholes have to be of substantial construction, a need which is emphasised in these days of heavy motor traffic. The minimum dimensions are: length 4 ft., width 4 ft., height 4 ft. 6 in., and these are increased as required, a very common type being 8 ft. by 7 ft. by 5 ft. 6 in. The method of construction may be briefly described as follows.

The trench is widened and deepened, and a 6-in. floor of concrete laid down, but with the thickness at the sides extended downwards to 9 in. to form footings for the walls, which are of 14-in. brickwork. An earthplate of 5-lb. lead, 6 ft. long by 1 ft. broad, is laid under the concrete, to be subsequently connected to every cable sheath by a 1-in. strip of lead, which is taken up the inner wall of the manhole. Provision is also made for the subsequent drawing-in operations by embedding in the concrete in each corner heavy wrought-iron ring-bolts, with large anchor plates bolted on below the concrete. When the concrete has set, the walls are built. Galvanised iron footsteps are built into the corner, above which the entrance is to be placed, and when nearing the roof-line the stone templates which form the supports for the roof joists are carefully set in position. The roof is as simple in construction as it is strong. The width of the manhole is bridged by rolled steel joists of 8 in. by 6 in. section. These, in turn, are connected together, and to the walls at each side, by smaller rolled steel joists (4 in. by 3 in.). Resting on these is placed a roofing of ½-in. boiler-plate. Above this comes 6 in. of concrete, and then a layer of asphalt. Above this the road is made up in the ordinary way, except at the entrance corner. Here a heavy cast-iron frame, 12 in. deep, is provided, into which fits a similar lid, having its upper surface filled in with wood blocks set in pitch. The inner walls of the manholes are carefully pointed, and the floor covered with a ¾-in. rendering of Portland cement. Fig. **43** gives details of a typical manhole.

Distribution Pipes. While it is necessary to have the main routes in the roadway, the distribution pipes must be as near to the shops and houses as possible, and they are therefore run along the footpaths. For this purpose, cast-iron pipes are used. These are classified, according to their internal diameters, as 2-in., 3-in., or 4-in. The first-named are made in 6-ft. lengths, the others in 9-ft. lengths, and the respective weights are 42 lb., 98 lb., and 154 lb. A 3-in. pipe placed on supports 5 ft. apart will support a ton and a half, and a jointed pipe, similarly tested will support a load exceeding a ton. They are coated with Dr. Angus Smith's composition, which prevents rusting and gives a glazed surface. Fig. **44** illustrates such a pipe. The left end is called the spigot end, and the right end the socket end. Bends of convenient dimensions are also provided.

In laying a line of distribution pipes, great care has to be exercised in the choice of the route. Allowance must be made for existing gas, sewer, electricity, hydraulic, and other mains, and in many cases the existence of under-footway coal-cellars makes special difficulties. Very often the line nearest the house-line is found to be the best, because not only is it most economical for distribution, but, owing to the fall of the paving to the roadway, the distance from cellar top to paving is here at a maximum. Ten men form a convenient gang; and when the foreman has chalked out the route, the paving is taken up, great care being exercised to avoid breakages, and the stones (where York or artificial stone is concerned) being laid so as to enable them to be returned to their original positions. While the first dozen yards of trench are being excavated, the jointing of three lengths of pipe is in progress. For this purpose four blocks of wood, with V-slots in them, are set up at (for 3-in. pipes) distances of about 9 ft. The spigot end of the second pipe is fitted into the socket of the first, and so on with the third; but before being brought together they are carefully gauged and examined to see that their interior surfaces are in order.

Into the annular space between the spigot and socket a length of spunyarn is inserted, being first wrapped round the spigot and then driven home by a caulking iron. Meantime, a roll of clay has been prepared by wetting and rolling on a board, and this is placed under the pipe and round the mouth of the socket, the ends being brought up above and curved outwards, so as to leave an opening into which molten lead may be poured. The space between the yarn and the clay is in this way filled with lead, which efficiently joints the two lengths of pipe. The clay is then removed, to be used again, and the cooled lead tightly caulked. A level bed having been prepared in the trench, small holes are made to receive the sockets, and the pipes are lowered into position. One joint in every four has to be made in the trench. A No. 8 iron wire is threaded through the pipes length by length as they are laid, to be used in the drawing in of the cable.

Under fair average conditions, a good gang can lay 100 yd. in a day of 9½ hours. Footway jointing-chambers of various sizes are provided at intervals not exceeding 100 yd., but they are usually required at more frequent intervals for distribution purposes. Six sizes are in use, varying from "double junction" boxes, 4 ft. 2 in. by 1 ft. 11 in., down to "distribution" boxes, 1 ft. 2 in. by 8 in. A concrete floor with Portland cement rendering is provided, and the sides built up of brick, the box proper being merely an iron frame designed to hold the iron lid, the top of which is filled in with stone. The connection between the footway boxes and the subscribers' premises is made by a length of 1 in. pipe. The connection between the roadway manhole and each of the adjacent footway junction boxes is in all cases made by three lengths of pipe.

Cable System. Having disposed of the pipes, we may now consider the cables more fully. It has already been mentioned that a short length of silk and cotton insulated cable connects the street cable to the main frame. This is for convenience of handling. The silk and cotton cable is made solid in the process of manufacture by filling it with beeswax.

The main distribution cables are varied in type, according to the purpose in view.

For serving subscribers near at hand, cables containing 1000 pairs of 6½-lb. conductor are used; for the next ring, 800 pairs of 10 lb. conductor, while for the outer ring cables of 300 pair, 20 lb. are available, the heavier conductor being necessary to provide for transmission requirements.

From the exchange basement the main cable runs through the ducts to the point where the main route is branched into two or three subsidiary routes by means of a Y or multiple joint. For instance, a twelve-hundred-pair cable may be connected to two six-hundred-pair cables or three four-hundred pairs. The whole joint is enclosed in lead, and sealed up by plumbers' wiped joints;

and to reduce the possibility of disturbance to a minimum, provision is made in advance for the anticipated development of the forthcoming eight years.

Main Cabling. The drawing in of the cables is known as *cabling*. In the case of main routes, it is first necessary to *rod* the pipes. Sweeps' rods, with patent trigger joints, which prevent unscrewing in the pipes, are jointed length by length and pushed through the ducts. They are then used to pull through (*a*) a spun yarn mop, (*b*) a circular brush, (*c*) a test piece of cable one yard in length, and (*d*) a 3-in. rope. (*a*) and (*b*) are used to clean the duct, (*c*) is examined to see if any obstruction may be anticipated, and (*d*) is to be used for drawing in the cable. The cable, which is mounted on a big wooden drum, may weigh from two to three tons, and is brought to the manhole on a low float. To enable the drum to be revolved, a steel axle is passed through its centre, and it is elevated on a pair of screw jacks. At the other manhole a winch has meanwhile been got into position, and the pulley rope brought round a pulley block anchored so as to be opposite the proper duct when the strain is applied. When all is in readiness, four men turn the winch handles and the cable is fed in, turning off the drum and through a large arc of a circle into the duct. A liberal dressing of petroleum jelly is applied in order to facilitate its progress [45].

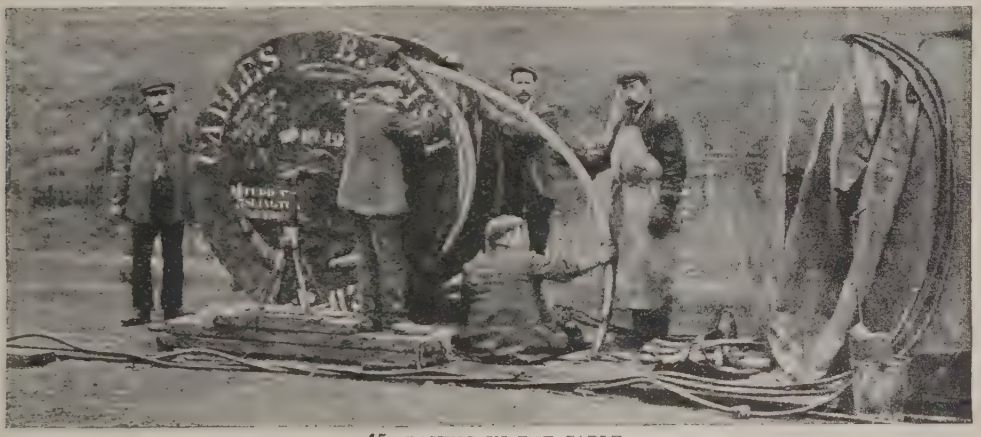
Motor winches have displaced manual labour to a considerable extent.

Similar operations, but on a smaller scale, are carried out in connection with the distribution cables.

Cable Jointing. Proceeding from the less to the greater, we will first describe the making of a joint between two lengths of seven-pair cable. The materials required are a lead sleeve, small paper sleeves for covering the conductor joints, some solder, some mixed resin and Russian tallow, lamp-cotton, thread, and wrapping paper. Everything must be kept properly clean and dry, and to this end a Gothic tent is usually mounted over the joint-box. The paper sleeves and wrapping paper are kept warm over a spirit-lamp. The lead sleeve is threaded on to one of the cables.

From each cable end a 6-in. length of lead is removed, exposing the outer paper wrapping, which is cut off back to the lead. The seven pairs of wires, each with its identifying coloured thread, are separated, in each case the thread being carefully looped round its proper pair. The arrangements for identification are so complete that when the jointing has been done properly a cable can be cut into at any point and any required wire picked out. To achieve this, the two wires forming a pair are wrapped one in red and one in white paper; these are the A and B wires respectively of the telephone pair. Round the centre pair of wires there is a white thread. This is No. 1 of the seven pairs. No. 2 has a black thread, No. 3 blue, No. 4 green, No. 5 two threads, one red and one black, No. 6 red and blue, and No. 7 red and green. Without unrolling the paper the whites of No. 1 pair are laid across each other at a point $1\frac{1}{2}$ in. from the ends, the white thread from one side being included. A few twists are made, and then the remainder of the paper is stripped off, and the copper conductors twisted together for a length of an inch. The twisted joint is then laid parallel with the wires, and a paper sleeve, which has previously been threaded on to one side, is brought over the copper joint. The other pairs are similarly treated, an expert jointer arranging that the joints are "staggered" so as to reduce the maximum diameter.

A wrapping of paper is then put over all, and tied down tightly with thread. The lead sleeve is now pulled over the conductors and set up vertically, so that one end may be soldered. A little wad of lamp-cotton is first pushed in between the cable and the sleeve, some tallow and resin come above this, and by means of a small spirit blow-lamp the opening is neatly closed with solder. The other side is similarly dealt with. It should be stated that before making such a joint the lengths of cable are adjusted, so that when completed the cable joint may be neatly trained round the box and fastened up along the side on a supporting bracket.



45. PAYING IN THE CABLE

Cable Codes. To facilitate reference and identification every cable has code letters allotted to it. Junction cables have four letters; main distribution cables, three letters.

The connecting up of subscribers takes place from the box outwards, and in a properly managed system plans are kept up to date, showing the position of every wire, both working and spare, and new subscribers are added without the slightest disturbance to those in existing cables, everything being planned out in the drawing-office, and complete detailed instructions issued to the workmen.

D. H. KENNEDY

Orchestration—continued. **Instruments in Combination. The String Band. The Full Orchestra and Theatre Band. Conducting and Choir Training.**

ORCHESTRAS AND CHOIRS

HAVING briefly described the instruments most generally in use in the modern orchestra, we may now consider the effect of them in combination.

The String Band. First in importance comes that group known as the string quartet, or string band. As has been already mentioned, this consists of a number of violins divided into firsts and seconds, a smaller number of violas, violoncellos, and double-basses. The relative numbers of these constituents vary considerably, but an ideal orchestra might contain 16 first violins, 16 second violins, 12 violas, 12 'cellos, 8 basses.

The beginner will perhaps be disposed to think that there is not much variety to be obtained from this one type of instrument, but a slight investigation of already existing music will speedily convince him to the contrary. Let us cull four examples at random, and note the immense contrasts of colour [Ex. 46–49].

In our first example, from Mendelssohn's overture to the "Midsummer Night's Dream," an effect of ethereal lightness is produced by the *pianissimo staccato* of the violins; the 'cello and bass, too heavy for this fairy music, are omitted altogether. Attention should be drawn to the fact that both the first and second violins are divided—that is, the violins are playing in four parts instead of two. This is a most valuable device in orchestral writing, and many composers have still further elaborated it by dividing certain sections of the strings into four, eight, twelve, or even sixteen parts; but it is doubtful whether the effect in performance justifies the labour entailed in the writing.

The device of dividing the 'cellos into four parts may be seen in our second example; the effect in performance is one of the most beautiful in the whole range of orchestration. In the third example is shown a solo for the violas and 'cellos in unison, with the basses accompanying pizzicato. Lastly, the strings are shown in a polyphonic movement—a word meaning, literally, many-sounding, but used synonymously with contrapuntal.

This is but a small selection of the different effects that can be produced by the strings alone. Before proceeding further, the student is recommended to take a selection of simple piano pieces and score them for string orchestra. The following suggestions may be helpful:

Beethoven. Sonata Op. 2, No. 2. (Slow movement.)
Beethoven. Moonlight Sonata. (2nd movement.)
Schumann. Papillons. Op. 2. Nos. 1, 3, 4, 5, 8, 12.
Schumann. Kinderscenen. (A selection)
Grieg. Lyric Pieces. (A suitable selection)
Schubert. Theme from Impromptu in B♭.
Rubinstein. Melody in F.
Chopin. Several of the Mazurkas.

A few remarks on the transcribing of pianoforte music for the orchestra will not be out of place at this point. Most young composers, from long acquaintance with the instrument, have acquired the habit of considering pianoforte music as the standard, and when they first attempt to write for the orchestra in nine cases out of ten they write first for the piano and then translate, as it were, their music into the orchestral idiom. This is a very natural procedure, and a by no means harmful one, provided a literal translation is not attempted, but the peculiarities of the orchestra kept in mind from the beginning. For instance, the number and position of the notes in a chord are limited, on the piano, by the fingers of the performer. Not so in the orchestra, where the performers are numerous. Thus the final chords of a piano piece may be illustrated as in Ex. 50. The top and bottom consist of a full chord, and the ear has accustomed itself to imagine the middle part to be filled in. But if we try this on the orchestra the gap in the middle would be painfully obvious; moreover, the thick harmony low down would be quite indistinguishable. It may be laid down as a rough rule that in a chord the parts should be tolerably evenly distributed; a larger gap is advisable low down (between the bass and the middle) than higher up. The natural series of harmonics given in Ex. 29 [page 5388] affords a good example of this treatment. So that our two chords should be scored as shown in Ex. 51.

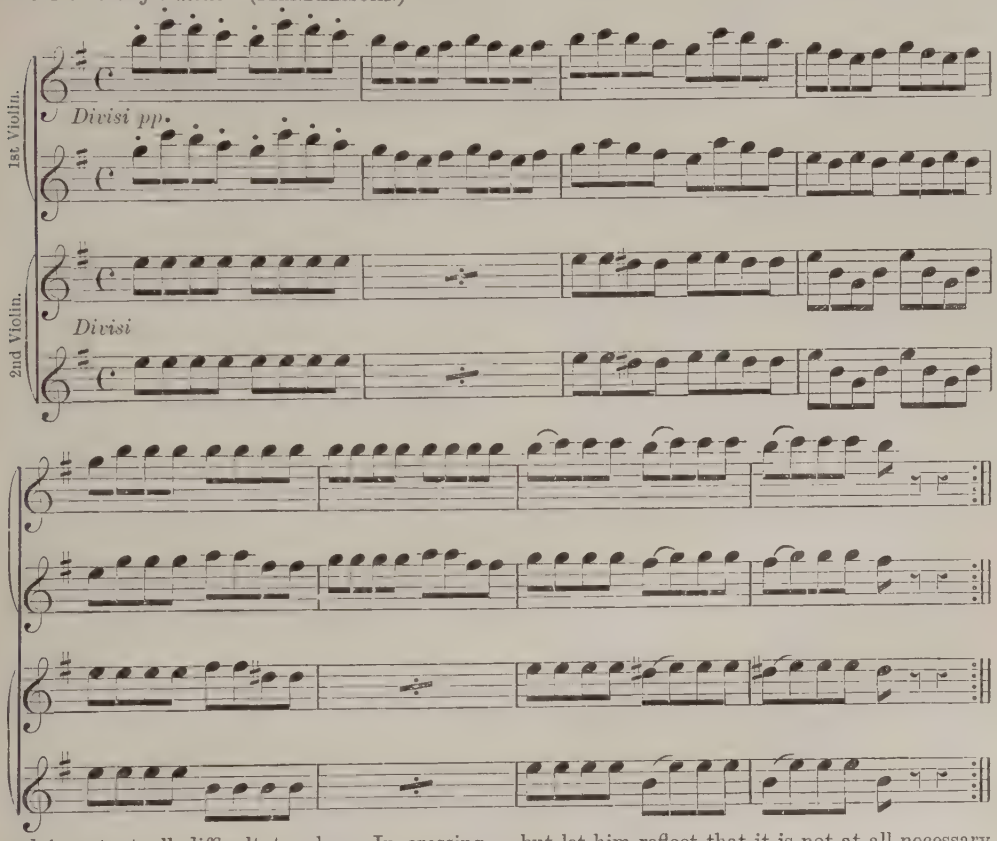
Acciaccaturas and Arpeggios. A device frequently met with in piano music to give the effect of widespread harmony is to write the bass note as an acciaccatura [52]. These notes are, of course, intended to be sustained by means of the pedal, and so the passage just given would be scored as shown in Ex. 53.

Another prominent feature of the piano is the ease with which extended arpeggios are played. There is no analogy to this in the orchestra, except on the harp. But the tone of this is so weak in comparison with the other instruments that it is hardly advisable to transcribe a pianoforte accompaniment as it stands for the harp. Some other means must therefore be sought for when translating this familiar feature.

Let us take a rather extreme instance. Chopin, one of the most pianistic of all composers, will furnish us with plenty. We select at random the Study in F major in the second book of Op. 10 [54]. The inexperienced student might think it possible to score this as it stands [55], but he

may be assured that the effect would be anything but pleasing; a passage so pianistic requires entirely remodelling to fit it for stringed instruments. In passing, however, attention should be drawn to the fact that when it is necessary to distribute a passage among different instruments, in order to avoid a "break" at the joins it is advisable to make the parts overlap—that is, to let the new part be taken up before the previous one ends [59]. However, even if this were done in the present instance the passage would still be uncomfortable, and to obtain the best result we must rearrange it, taking advantage of our knowledge of the violin family to make it lie well for the instruments. The translation given bears a considerable resemblance to the original,

Ex. 46. *Allegro molto* (MENDELSSOHN)



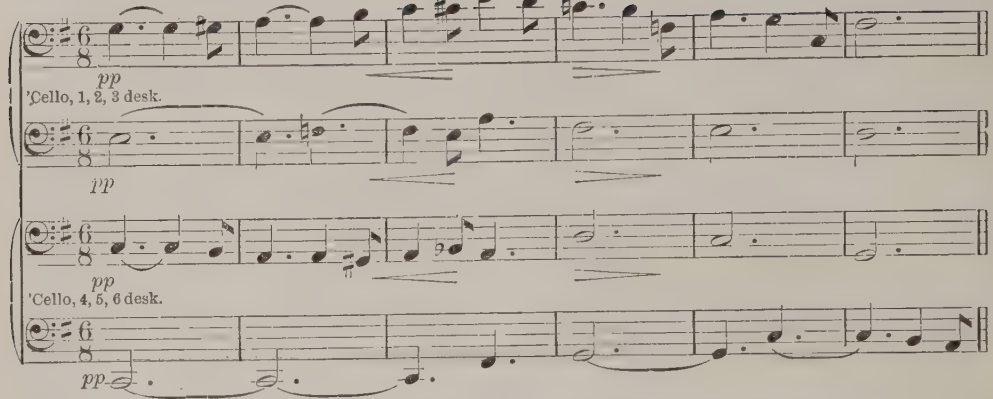
and is not at all difficult to play. In crossing the strings every use is made of the open notes [56]. But this is not the only possible version. Here is another even easier, though less closely resembling the original [57]. A few typical passages may here be given with a suggestion for their treatment, the device of double-bowed notes proving exceedingly useful [58, 60, and 61].

The Full Orchestra. The term "full orchestra" is used to denote the collection of instruments generally found at the principal London concerts, and for which modern composers are accustomed to write. It consists essentially of a fairly large and tolerably well balanced body of strings; wood-wind represented by two flutes, two oboes, two clarionets, two bassoons, with the addition, ad libitum, of a piccolo, cor anglais, bass clarionet, and double bassoon, and, on occasion, even further reinforcements; four horns (occasionally six or eight; these instruments are always employed in pairs), two or three trumpets, two tenor and one bass trombone, one tuba (these last forming a quartet of brass), two or three timpani, and other percussion instruments at the pleasure of the composer. A harp is a not infrequent addition.

The beginner will feel at a loss to know how to dispose of this great mass of instruments, but let him reflect that it is not at all necessary for all of them to play at once. In his first attempts at scoring he will do better to err on the side of thinness than the reverse, to which end he should start by writing for small orchestra, or, better still, for theatre band. Let him consider the wood-wind as the solo stops, as it were, of an organ, impressing his mind early with the precise tone-colour of each instrument.

It will be as well if, at this point, we consider the wood-wind apart from the rest of the orchestra, and afterwards endeavour to combine them with the strings. And, first, as to the tone-colour of each separate constituent. Can anyone who

Ex. 47 (WAGNER—"Siegfried")



has heard Dvorâk's New World Symphony forget the luscious effect of the flute low down in the phrase? [62] A typical instance of the higher register of this instrument may be found at the beginning of the second act of "Carmen," where two flutes play [63]. Owing to the flute's excessive delicacy the greatest care is necessary in accompanying a solo; strings should be almost invariably employed for the purpose. It may be stated, as a rule, that when a wind instrument has a melody, another instrument of the same kind should not be in use. This does not apply to the example above, where the two flutes in thirds form the essential feature of the melody.

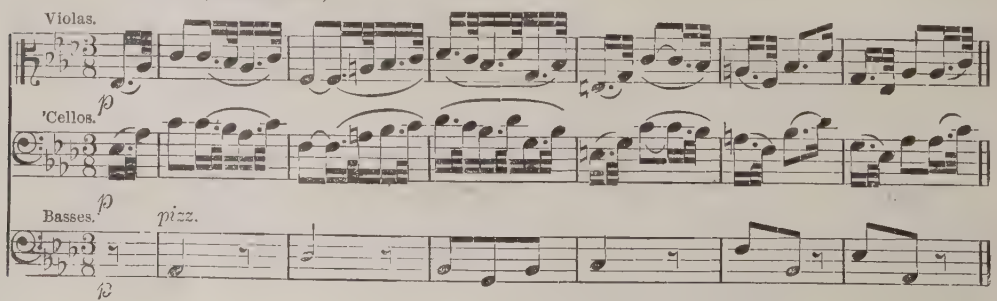
The oboe in solo work is best kept in the middle of its compass; the lowest notes are a trifle coarse, and the highest inclined to be squeaky. Its tone is so distinct from any other instrument that it will probably be the first the student will learn to recognise. It is well adapted to pathetic phrases and less suited to lively music, although, from its association, it is frequently used for a pastoral effect. One quotation will suffice, which, although rather high, is effective [64].

The clarionet is, perhaps, the most useful of all the wood-wind, partly on account of its extensive compass. Its tone-colour in the higher register differs considerably from that of its lowest octave, consequently it is possible to make an exception to the rule given above and allow a melody on one clarionet to be accompanied on another. The clarionet seems to have been Weber's favourite instrument, and a glance at almost any of his scores will reveal many beautiful and characteristic instances of its use. For solo use in the orchestra the bassoon has commanded less attention than it deserves; it has great expression of pathos on its higher notes, though florid passages low down invariably sound grotesque and comic. Beethoven, who treated all instruments with loving partiality, has left us some charming specimens of bassoon writing. Note the contrast between the mournful solo in the Rondo of the Violin Concerto [65] and a passage from the Fourth Symphony [66].

Besides these "primary colours" there are numberless others to be obtained by a judicious combination of wood-wind. A few of the simplest may be briefly mentioned. Flute and clarionet in octaves, usually with the former above the latter; a very sweet tone results from this combination if the music lies in a suitable register. By substituting an oboe for the clarionet the tone loses something of its pureness, but is rather more penetrating. Clarionet and bassoon in octaves is also effective if the melody does not lie too high. When more than three instruments are combined on one part the tone-colour loses distinction but gains in intensity, and additional instruments make but little difference except in tone-quality.

Although not strictly of the wood-wind class, the horn bears a decided resemblance to those, inasmuch as it combines beautifully with them and, furthermore, has valuable properties as a solo instrument. Its soft, dreamy tone in *piano* is unapproachable. In addition to this its tone in a *forte* is quite "brassy"; a passage for horns such as that shown in Ex. 67 has

Ex. 48. *Andante* (BEETHOVEN)



almost the effect of trombones. Since there are four of them in the orchestra, four-part harmony on horns is possible and exceedingly effective. Considerable use is made of them, moreover (especially by German and modern British writers), for filling in and sustaining the middle parts of the harmony, which gives an effect of fulness to the music; but this should not be indulged in to excess, as it results in monotony of colour.

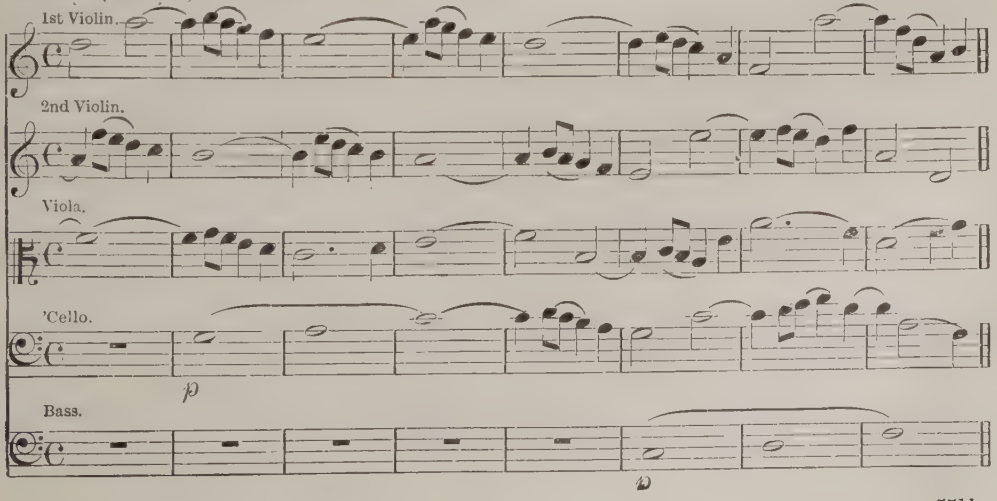
Now let us combine our forces, and add thereto a couple of trumpets, three trombones, and a pair of kettle-drums (timpani). This brings before us another question, balance of tone—that is, the different degrees of sound intensity possessed by each instrument. Until we know something of this it will be impossible to say, in any given passage, what will predominate. Normally, the highest part will stand out more than a middle one or the bass. But the matter is more complex than this. Score a few bars suitably for full orchestra, mark each part off, and what is the result? You will hear the trumpets, trombones, and drums; if the violins are written high up you may hear them to some extent. The wood-wind are inaudible.

Having learned from this which instruments can play the loudest, let us inquire which are best able to play *pp*. The honours are fairly divided here, but again the timpani may be considered to hold first place with an almost inaudible roll, followed closely by the strings, horns, and the low notes of the clarionet and flute. With these two exceptions the wood-wind are least able to play *pp*; that is, they have the smallest range of tone of any save the harp. This latter instrument is the first to be swamped by horns and wood-wind, and must be written high up if it is to be heard at all. In a *forte* without brass the strings have it all their own way, unless the wind are massed together high up, and even then the balance will not be good. In a passage from Beethoven's Fifth Symphony [68] it is probable that the imitation on the wood-wind has never been heard; if it has the conductor was responsible, not Beethoven. The weakness of the wood-wind when played against the strings *forte* has been insisted on at some length, as it is a fact invariably overlooked by the beginner, and his disappointment at finding a choice counter-subject rendered inaudible from this cause is generally the best reminder of the futility of his scoring. He is then apt to acquire an exaggerated idea of the weakness of the wind, and if he scores a pianissimo melody for, say, a solo 'cello with a light wood-wind accompaniment he will be horrified at the loudness and coarseness of the latter. This merely bears out what was said of the smallness of the wood-wind's range of tone. When anything like delicacy is wanted for an accompaniment the strings are unapproachable.

We are now in a position to score some simple pieces for full orchestra. The Menuetto from Grieg's Piano Sonata in E minor will be easy and effective for a first attempt. The opening might be given to the strings—it must be remembered that it is not necessary to lay out the harmony in "handfuls" when dealing with the orchestra; at the *fortissimo* the tone should be reinforced by the addition of the wind and brass, keeping the wood-wind high up and the brass nicely laid out over the harmony, the violins, perhaps, in octaves on the melody. At the double-bar the melody in thirds would fit two clarionets, accompanied by strings. The accents on the second beat might be reinforced with other instruments. The trio will afford a good opportunity for the wind and strings to be used antiphonally. Score the first eight bars for wood-wind alone; the flute had better have the top part, and the bassoons may be omitted or not, at pleasure. The succeeding eight bars should be strings alone. At the return of the minuet it would be well to vary the treatment somewhat, for the sake of variety.

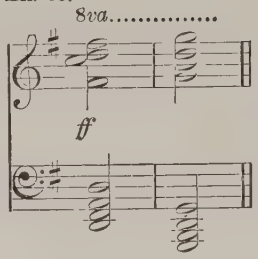
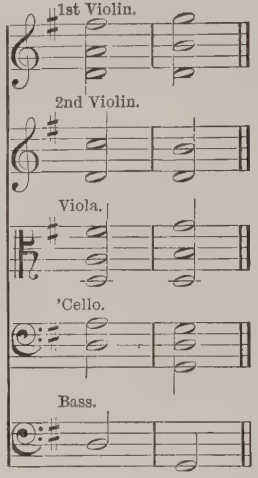
Other pieces suitable for full orchestra will readily occur to the student. Beethoven's Funeral March from the Sonata Op. 26 offers good scope, Schumann's Carnival (a selection),

Ex. 49. (MOZART)



many of Schubert's marches, and Dvorâk's "Bohmer Wald" piano duets, although more difficult, would be very effective.

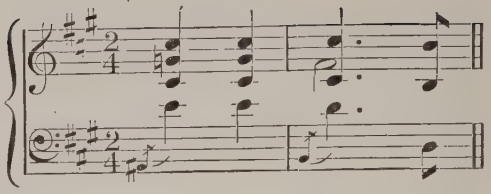
Before we can make any progress in modern orchestration it is, above all things, essential to the student to hear his work performed, however badly; and at that performance let him listen with all his intelligence alert, analysing every sound and comparing it with what his imagination had depicted. He will learn more from hearing and comprehending his errors than from pages of written instructions, provided he has acquired the groundwork, the technique, as it were, of orchestration. Much can be done from the study of scores, but only those he has heard and well remembers the effect of in performance. It will take years of experience before he can realise the sound of a score he has never heard.

Ex. 50.

Ex. 51.

We can but briefly refer to the other varieties of orchestra previously enumerated.

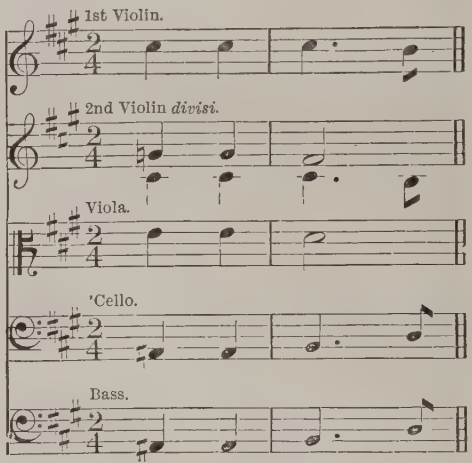
The Small Orchestra. The small orchestra, as written for by Beethoven and his contemporaries, is only the full orchestra with the trombones and the second pair of horns and all extra percussion omitted. The strings are also assumed to be reduced in number, and extra instruments, such as piccolo or cor anglais, are not admitted. Both in treatment and effect this orchestra may be considered to stand midway between the full orchestra and the theatre band, which latter will repay more detailed consideration than it generally receives.

The Theatre Band. The theatre band in its ideal form consists of these instruments: one flute, one oboe, two clarionets, one bassoon, two horns, two cornets, one trombone, one pair of timpani and various percussion, and a small selection of strings. With a band of these proportions the most charming effects can be produced, but alas! it is frequently found to be in a sadly mutilated condition. The horns may be missing, or the bassoon, then the second clarionet is dispensed with, and finally, from motives of economy, it is reduced to the septet band—string quintet, flute and cornet! Nevertheless, there are quite good theatre bands to be found in London and elsewhere, and we may devote a little space to their consideration, because it is most probable that the student's early

Ex. 52. (SCHUMANN)



Ex. 53.

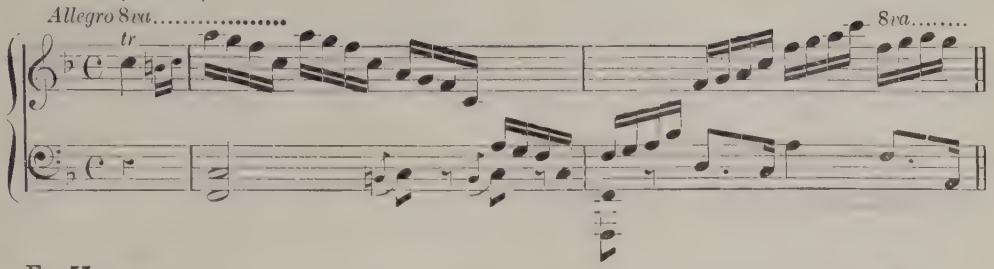


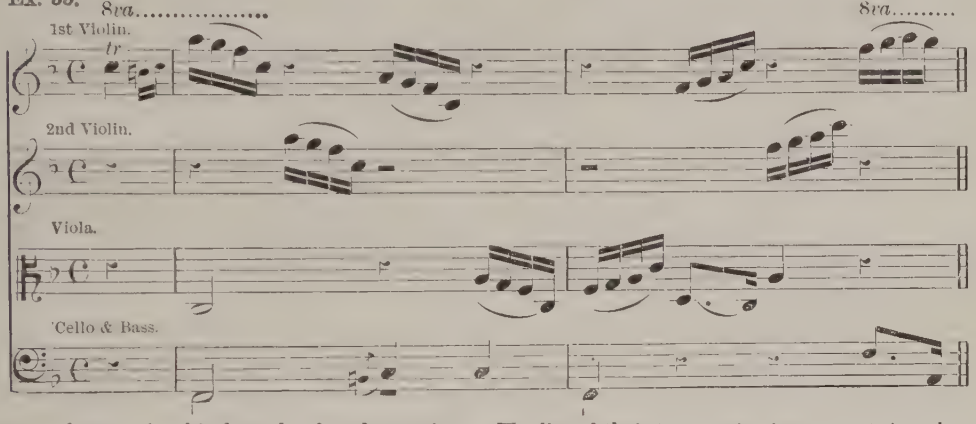
attempts will gain a performance by this combination.

The methods employed with the full orchestra will want some revising for this differently balanced force. Take the brass for instance; the one trombone (a tenor) is apt to appear useless to the beginner, but by writing the cornets low down, three-part brass harmony is possible, and the horns may assist. The first cornet is perfectly well able (and willing) to play the melody, but is easily made to sound vulgar in this capacity, and for artistic scoring these useful instruments should be considered a compromise between trumpets and trombones: moreover, in the absence of horns they will make an efficient substitute.

The principal use of the wood-wind will be for solo work, but owing to the paucity of strings they seem to possess more sonority than usual. The clarionets and bassoon may be used for sustaining harmony in the middle.

But it is upon the strings that the chief burden of the orchestra will rest. Even more than before is this the case, and it is but seldom that we can afford to leave them out entirely. Owing to their small number it is not often advisable to divide them, although this has been done at times with wonderful effect. It should be remembered that as the orchestra is somewhat sunken the scoring may be made rather thicker and noisier than would be good for the concert platform. But much will depend on the purport of the music; if it is incidental music, to be spoken through, it cannot be made too light, and the wind had better be eschewed almost entirely. There is

Ex. 54. (Chopin)

Ex. 55.



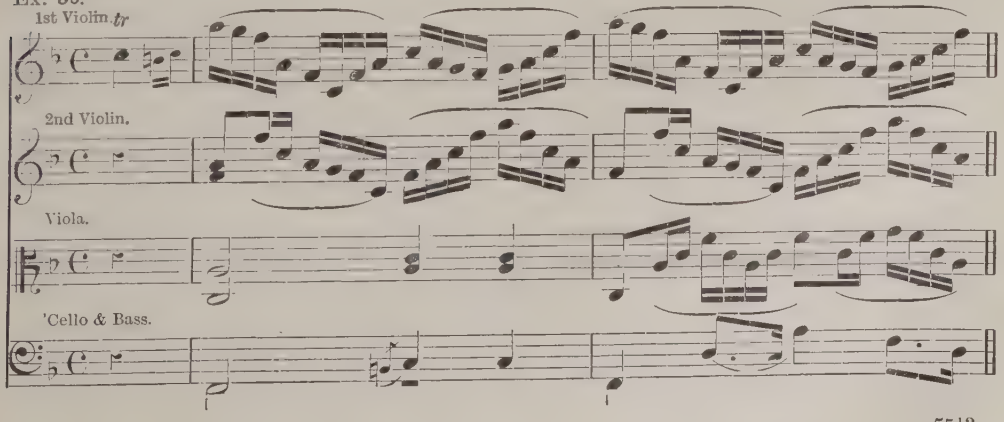
plenty of scope in this branch of orchestration for improvement; the ordinary composer of light music seldom troubles to think out new effects of scoring.

The Wind Band. The wind band, as found in this country, is not a very artistic combination. It consists, approximately, of flute, oboe, two clarionets, two horns (sometimes omitted) two cornets, trombone (sometimes two), euphonium and side-drum, thus bearing considerable resemblance to the theatre band minus the strings. It is unnecessary to say more of this than has already been written; only the simplest kind of music is suitable for such treatment.

The Brass Band. The brass band, such as is heard chiefly in the North of England, approximates somewhat to the military band. The list of their transposing instruments is rather terrifying. The latter is constituted something as follows: Piccolo in E♭, flutes in D♭, oboe, clarionets in E♭, first clarionets in B♭, second clarionets in B♭, third clarionets in B♭, alto clarionet in E♭, four horns in E♭, two cornets in B♭, two bassoons, two trumpets in E♭, two baritones in B♭, two euphoniums in B♭, three trombones, two bombardons in E♭, contrabass tuba in B♭.

In the brass band the wood-winds are omitted; sometimes the clarionets are substituted by saxophones, which take the place of violins; failing these the cornets take their place. It is unlikely that the student will want to write for either of these combinations, moreover some acquaintance with the technique of the instruments is almost a necessity.

Ex. 56.



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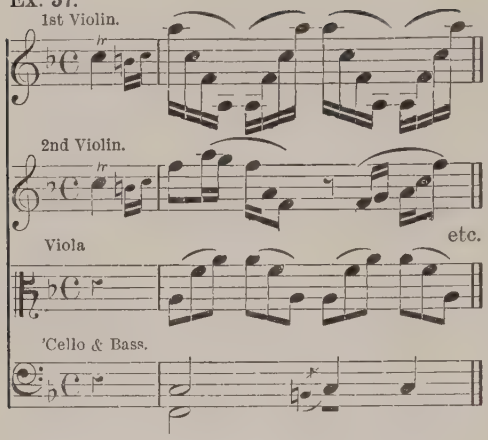
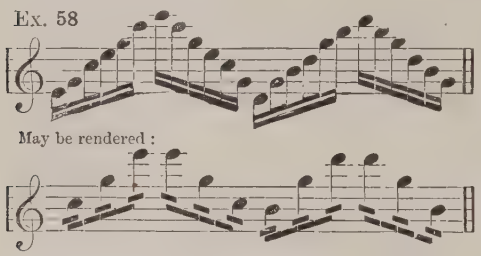


In conclusion a few practical hints may be of service to the inexperienced student. The order in which the instruments are arranged in the score has undergone some modification, but the most usual, and the one which cannot be bettered, is this. First, the wood-wind in order of pitch (reckoning the lowest note of each); the horns, followed by the rest of the brass; next the percussion (to save space they may, with the exception of the timpani, be written on a single line); the harp (if used). In a vocal work the voices may come next, and, lastly, the strings.

Ex. 58

Piccolo, flutes, oboes, cor anglais, clarionets, bass clarionets, bassoons, double bassoon, horns, trumpets (cornets), trombones, tubas, timpani, triangle, bass drum, etc., harp, voice, first violins, second violins, violas, 'cellos, basses.

The voices are sometimes put in the midst of the strings, just above the 'cellos, but it is better to keep the strings together.

It is customary to put reference marks at short intervals in the score to facilitate matters at rehearsal. Letters are frequently used, inserted usually at the beginning of a phrase or other likely starting-point. A still better device is to number every tenth bar consecutively. This affords additional protection against bars being left out by the copyist.

In copying out band-parts it is well to endeavour to bring a "turn over" at a point where the instrument has a few bars' rest, even if this necessitates wasting half a page of paper. If this is impossible it should be arranged that the string parts each turn over at a different point. For the same reason the two flutes are written in parallel staves on the same paper, and the other wind correspondingly, so that the second may turn over if the first is playing at the end of a page. After a good many bars' rest it is safest to write in a "cue" in red ink, previous to the instrument's re-entry. Attention to these details will assist in obtaining a smooth performance.

CONDUCTING

Anyone who has ever taken part in a pianoforte or vocal duet must have experienced some little difficulty in keeping strict time with his fellow performer. Failure in starting together, and the slight fluctuations of time that are necessary for a musical performance, are generally the blots on such duet playing. If he has played in a quartet the student will have observed this difficulty still more strongly; a nice *ensemble*, as musicians call it, is only to be obtained by constant practice, until not only the work under performance but each of the players' idiosyncrasies become familiar to all the performers. If, now, we imagine a performance by from 20 to 100 instrumentalists, the difficulties will be immeasurably increased. How are they to decide simultaneously the moment of starting? How agree upon the precise *tempo?* (The Italian word "tempo" is used throughout to denote the rate or speed of performance; time, the English equivalent, refers always to the time-signature—that is, the number and value of the notes in the bar.) How, in short, can they give a performance that shall be in any way unanimous without an infinitude of rehearsing? It will at once be obvious that there must be one master mind to direct the powers of the others, and that these must, for the time being, be subservient to the director. We may gather from this what are, in part, the functions of the conductor in the orchestra or choir.

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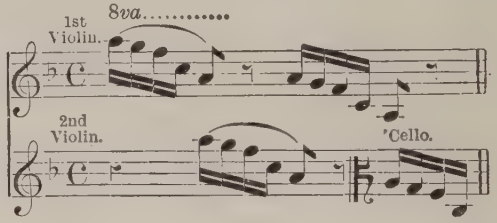
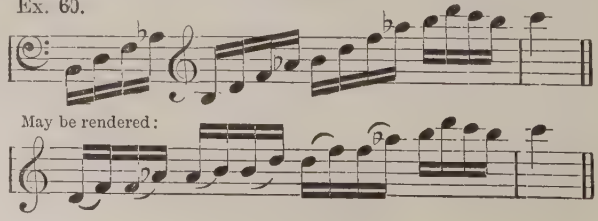
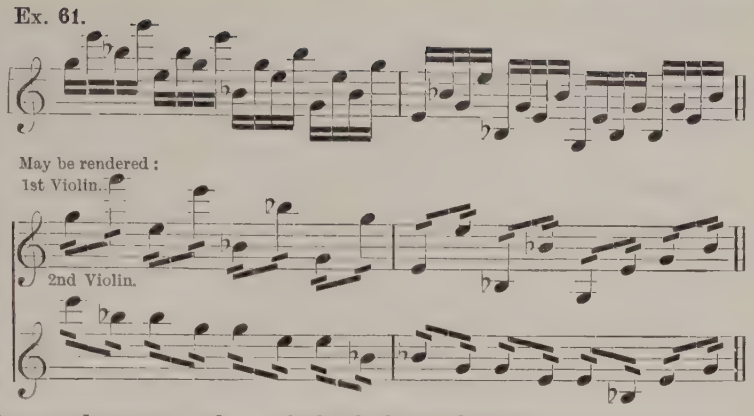

Until about eighty-five years ago the orchestra was conducted by the joint efforts of the principal first violin (who is still called the leader), and a pianist, whose duty it was to fill in any obvious gaps caused by the faulty playing of the

Ex. 60.



orchestra. This unsatisfactory state of things continued (in England) until 1820, when Spohr, conducting the Philharmonic concert in London, directed the performance with a *baton*, a light staff of wood with which he beat time and gave the necessary indications to the band. The immense superiority of this method was so apparent that it soon became universal and has remained so ever since.

Ex. 61.



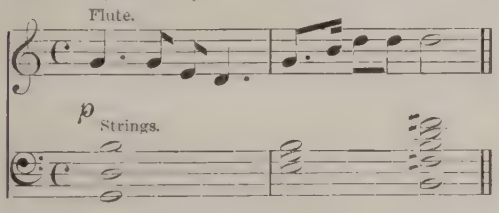
The requirements of a conductor may be grouped under two heads: (1) The technical knowledge of the code of signals and gestures used to indicate the different times, rhythms and nuances (light and shade); (2) the æsthetic knowledge of the requirements of the music. It is only the technical side of conducting that can be taught here on paper; the æsthetics of music can only be learned by an exhaustive study of the scores and by listening to performances under the best conductors.

It is necessary that every movement of the conductor shall be deliberate and decided. Any hesitation that he may show will be reflected by the players under him, his indecision will be shown by them, hence he must be very certain of what he has to do. The baton must be held lightly, and the arm and wrist should be free. The baton should be kept sufficiently high to permit of its being seen by everyone, yet no higher than is necessary or the arm will quickly become tired.

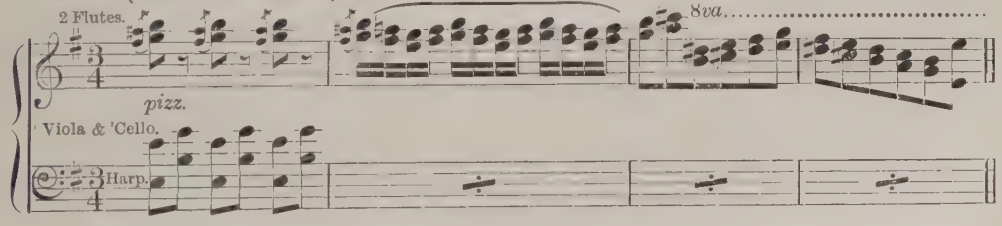
The student will probably know enough of musical theory to remember that the first beat of every bar is the most important; it has normally the strongest accent, and is invariably indicated by the conductor by means of a down beat [1]. The down beat should never be used except on the first of the bar; it follows that the preceding beat—that is, the last of the bar—will be upwards. The remaining beats will be filled in variously, according to circumstances. The principal varieties may be thus tabulated, the direction of the beat being shown (approximately) by means of diagrams. Two in a bar, first down, second up [2]. In a very slow movement in duple time it may be necessary to beat four in the bar. Three beats in the bar, first down, second either right or left, third up [3].

If any of the players are seated behind the conductor the second beat should be to the right, so as to be more visible; if all are in front of him it is quite immaterial which

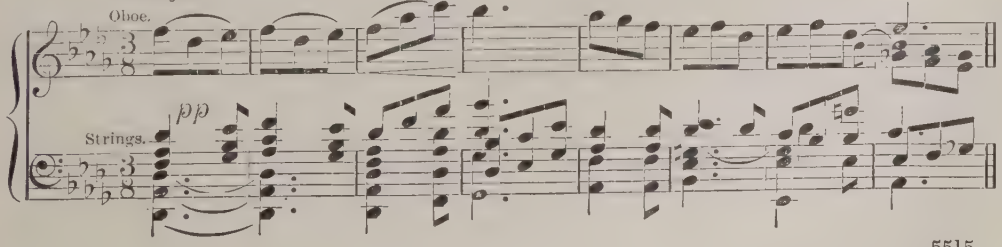
Ex. 62. (Dvořák)

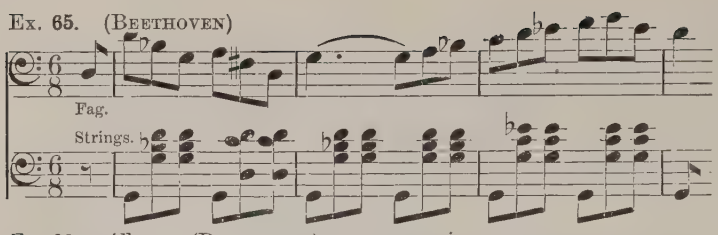


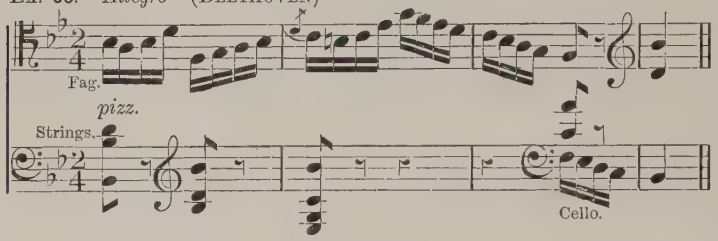
Ex. 63. (Bizet—"Carmen")



Ex. 64. *Adagio*



Ex. 65. (Beethoven)

Ex. 66. *Allegro* (Beethoven)



direction is taken. In a very fast 3–4 movement, such as the scherzo of Beethoven's Pastoral Symphony, there is no time for three separate beats, and "one in a bar" should be indicated by means of a decided down beat on the first and a quick up-beat at the end of the bar.

Four beats in the bar, first down, second left (generally), third right, fourth up [**4**]. Some conductors reverse the directions of the second and third beats.

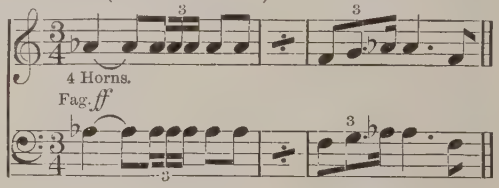
Six beats in the bar. This will be indicated in two different ways—according to whether the time be compound duple (6–8 or 6–4) or a slow triple (3–2 or 3–4). The former case will require two strong beats on the first and fourth of the bar, each followed by two lesser beats [**5**]. The latter will be similar to three beats in a bar with each beat duplicated [**6**]. Six and more beats are only required in very slow tempo, as they will all be found to be compound varieties of duple, triple, or quadruple times.

Eight and twelve beats are both compound varieties of four in a bar, each beat being duplicated for eight, or triplicated for twelve [**7**], while nine [**8**] is three with each beat triplicated.

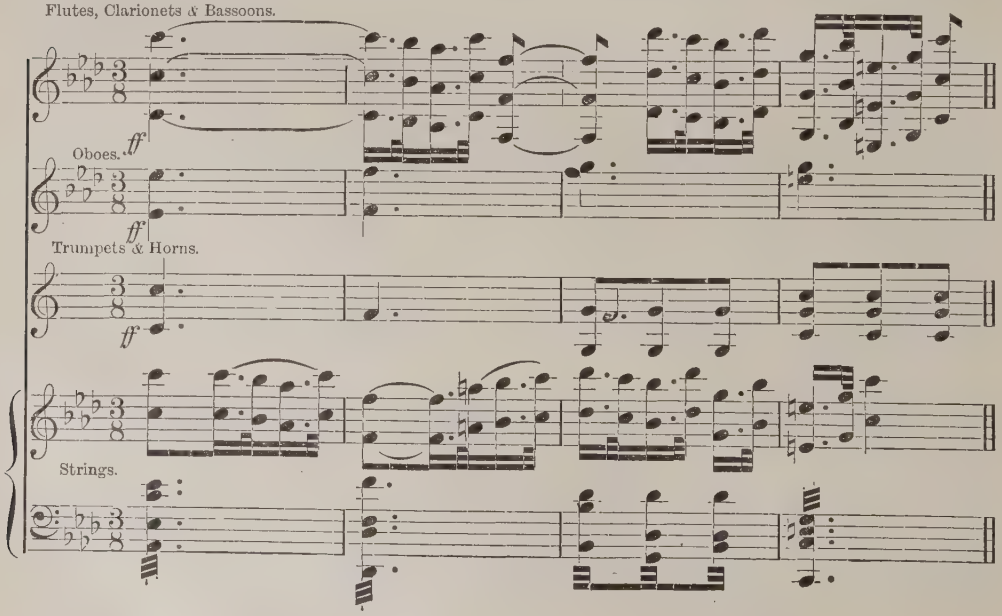
The irregular rhythms of five and seven beats in a bar. These will generally be found to consist of a bar compounded of alternate two and three, or four and three, and may be beaten as such if the first of the bar be made clear. Or five may be beaten as diagram **9** shows.

The movements necessary in beating time should be made freely and decisively, without being jerky. They should be so familiar as to be performed semi-automatically, so that the conductor's whole attention may be given to the requirements of the music. Nothing could be more disastrous than to find the conductor

Ex. 67. (Tschaikowsky)



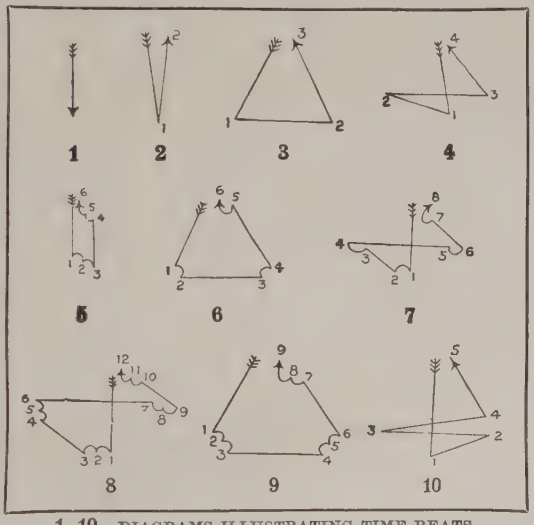
Ex. 68. (Beethoven)



unprepared for a sudden change of time. This, of course, requires that he be well acquainted with the work under performance, and however great his talents, he should not permit himself to follow the example of a certain well-known musician who makes his acquaintance of a new work while he is conducting the first rehearsal of it.

At the start of a piece or movement the baton should be held poised in the air for a few seconds until the conductor is sure of the attention of the whole orchestra, and the first down beat should be prefaced by a short up-stroke, which will have the effect of giving a more decided and definite start. If the music begins on some beat other than the first it is not advisable to beat the whole bar (unless it be indicated in the score by rests), as this may cause confusion to such of the orchestra as are counting several bars' rest; but the starting beat should be preceded by a slight preparatory movement.

Exaggerated Gestures. Apart from the actual beating of time, numerous other indications as to the manner of performance can be given with the baton or by means of gesture on the part of the conductor; but a word of warning must be given against the habit of exaggeration in gesture. Nothing looks worse than to see a conductor enacting movements of fury in order to obtain a *con fuoco* from his band. Any special climactic effects should be spoken of at rehearsal, and a slightly broader gesture may be used in performance by way of a reminder. A pause on a note is held by keeping the baton stationary on whatever beat it occurs—usually the first or strong accent. It is released by a short upward flick of the end of the baton. There should always be a brief interval of silence after a pause on a note before continuing. A pause on a rest is, perhaps, better indicated with the baton held poised in the air as at starting.



1–10. DIAGRAMS ILLUSTRATING TIME BEATS

At the conclusion of a piece the sound should be sharply cut off by a quick upward flick of the baton. It may be taken as a general rule that light and *piano* characteristics should be accompanied by small and delicate movements, chiefly from the wrist, the increasing size of the beats to correspond with the increase of tone required and the gesture becoming broader as the music does likewise. It is assumed that the baton is held in the right hand, but it is often advisable to use the left hand with it for supplementary gestures, indicating breadth and climax—indeed, many conductors use the left hand as much as the right, and would probably be unable to keep it still without an effort. The left hand can also be used for a gesture signifying extreme softness; this is especially useful for a sudden *piano*.

The Position of the Players. When any instrument has had a number of bars' rest it is well for the conductor to make his re-entry certain by giving him a signal. A glance in the direction of the player or players just preparatory to their re-entry will afford the necessary indication for their guidance. It follows that the conductor must know the position of each instrument in the orchestra. This varies a little according to circumstances. In a theatre, band space is usually restricted, and the conductor may congratulate himself if his trombone and timpani are not outside in a passage where he cannot see them! But in the concert orchestra the arrangement is usually thus, from the conductor's point of view: The first violins are on the left, the seconds on the right, the violas in a line in front, the 'cellos sometimes behind the violas, but frequently divided right and left as are the double-basses. Occasionally they play at the same desk as the latter—that is, one 'cello and bass to each desk—this is behind the violins. The woodwind (flutes, oboes, clarionets, bassoons) sit in a line behind the violas; if the space is small they may be in two rows; behind them are the horns and trumpets, the trombones and percussion occupying the backmost seats. If there is a harp it is placed as near the conductor as possible. This is necessary partly on account of the weak tone of the instrument, but also because the harpist requires more personal attention than the rest of the orchestra.

This arrangement must not be taken as invariable, but merely the usual disposition of the band at London orchestral concerts.

The Conductor's First Performance. Now, our first experience of conducting may occur in several ways. The composer may be asked to conduct a performance of his own work by a more or less well-known orchestra (not otherwise will the student be permitted to experiment on a good band), or he may get together an amateur orchestral society and appoint himself conductor, or he may possibly obtain the conductorship of a theatre band. We will consider each of these possibilities in turn.

If it is his own composition that he is conducting, the student starts with one great advantage; he knows the work in question

thoroughly at the start, and can give all his attention to what he is doing. Very probably there will be only one rehearsal, so he must make the utmost of his time. His first undertaking will be to see that the band parts are all correct, for, however carefully he has looked through them, there will always be mistakes somewhere. He must listen very carefully in order to detect which instrument is in error, and the moment he stops to effect an alteration he will find half the band clamouring to have mistakes, hitherto unsuspected, rectified.

These preliminaries require a clear head and a well-trained ear, besides unlimited patience, if they are to be gone through successfully. If the orchestra is composed of good and experienced players, it is not advisable to stop them too often, except to set right anything important, as they can be trusted to notice and correct little errors for themselves, and it is impossible to get an idea of the music as a whole if the band is stopped every few bars. Any fluctuations of time (*ritardando* and *accelerando*) will be indicated in the parts ; this will warn the band to follow the beat carefully ; but such changes of tempo must be very clearly shown, and must not be made too abruptly.

The Limitations of Amateurs. It requires considerable courage for the beginner to conduct another man's well-appointed orchestra for the first time ; but, given a band of amateurs, the youthful conductor, if he has had any musical training, may feel far more confident and despotic. He should be warned, however, not to be too ambitious, but to suit his programme to the capacity of his orchestra ; for the majority of amateur instrumentalists are, to say the least of it, indifferent readers. So it will often be advisable to take to pieces any difficult passage that may present itself, rehearsing, say, the wood-winds alone, to obtain the necessary *piano*, the violins by themselves (more especially the seconds) until they can play that semiquaver passage nicely together ; the brass, if there is any, that we may hear who it is playing a wrong note, and so forth. Before conducting well-known works the student must ascertain the correct tempo throughout, and should not deviate from the traditional reading without sufficient reason until some years of experience lie behind him.

Conducting Theatre Bands. We now turn to the theatre band. This is a capital medium on which to expend one's embryo efforts of conducting, besides being a fruitful source of experience. Its composition varies from the string quartet, cornet, and piano of the provincial "smalls" to the well-developed orchestra now to be found at a few of the best London theatres. It differs in many respects from either of the varieties of orchestra that we have so far considered. It is smaller in size ; it occupies usually a more enclosed space ; is frequently out of sight of the listener, and it is not listened to with very much attention. It is on account of these seeming drawbacks that the band is more easily controlled by its conductor. He can do things which would be impossible in a concert-room ; on an emergency he may even speak with the players. The necessity for this facility of control is seen when the band is playing music incidental to the stage performance. It may have to follow the action of the play, which only the conductor can see ; he may have to make sudden alterations of tempo, pauses where none exist, repeat sections *ad libitum*, or leave out repeats.

Impromptu Work. At times the conductor may have to give out band-parts and perform at sight extra numbers to fill in a delay between the acts ; in the middle of this the curtain will perhaps rise, and the conductor must stop abruptly at the nearest cadence. This sudden stoppage can be indicated to the band by a look and an appropriate gesture ; a *ritardando* will even suffice for the experienced bandsman. If there is no possible stopping-place in the music a *diminuendo* until the sound is practically inaudible is the only resource. In dance music, where every section is marked with repeats, the conductor is accustomed to tap the desk twice in quick succession to indicate "Go on, omit the repeat," where such omission is desired. It will be found that much light music of which band-parts are obtainable is unprovided with a full score, and the conductor has frequently to be satisfied with a first violin part ; but music of this character is so simple that this is not a great drawback. In very small orchestras the conductor may be expected to play first violin himself, leaving off to beat time with his bow when necessary.

CHOIR TRAINING

In writing for the purpose of assisting the inexperienced student over his earliest attempts at choir training, it is necessary to consider in what circumstances he is most likely to need this assistance. It is not in connection with a well-appointed choral society that these initial efforts will take place. We are writing, be it remembered, of choir *training*, not choir *conducting*, and in order to obtain a post as choirmaster to an even moderately good choir a certain amount of previous experience is almost a necessity. It is probable that the student's first efforts will be expended on a small and very indifferent church choir, the post of choirmaster not infrequently being combined with that of organist.

That such a choir will most likely be small, badly balanced, and badly trained (or else not trained at all) is in some respects an advantage, as the opportunity is offered of learning the work from the very beginning ; and if the student is anything of a musician he will instinctively realise how much there is for him to do, and in his energetic attempts to reduce chaos to some order he will lose that feeling of "newness" to the task, and experience will rapidly come to him.

The Arrangement of the Voices. A choir, if it is to be worthy of the name, should be divided into four parts or voices—trebles, altos, tenors, and basses, and this arrangement should be adhered to wherever possible, as by far the greatest amount of choral music is written for this combination of voices. The first difficulty

to be encountered is to select the members for these four parts so that a tolerable balance is obtained. If the trebles are sung by boys' voices, as is very usual, they will require to be more numerous than the other parts; indeed, they may be equal in number to the other three combined without causing any serious disproportion. The altos generally give the choirmaster the most trouble. If there are ladies in the choir, well and good, but if not, the male voice is rare and difficult to obtain, and boys' voices will have to be employed for these. A fair proportion for a choir of 20 would be: 10 trebles, 3 altos, 3 tenors, 4 basses. If the trebles are sung by women the proportion to the other parts may be rather less. Thus our choir of 20 might contain 8 trebles, 4 altos, 4 tenors, 4 basses. Perhaps a further improvement would be an additional bass or two.

It has been said that the functions of organist and choirmaster are generally united in one individual, hence it will be obvious that at the preliminary practices any organ accompaniments are out of the question; the choirmaster will want to give all his attention to conducting the choir, any accompaniments that may be necessary to preserve the intonation (and the less the better) can be played on a piano.

Preliminary Instruction. It will perhaps be as well if we assume that the choir we are considering is entirely new-formed, and has had no previous training. Our first care in this case should be to take the younger members by themselves and impart some instructions in the rudiments of music, paying more especial attention to such matters as concern the relative values of notes and rests, time signatures, and the like. A blackboard ruled with music lines should be provided, and exercises in time written thereon should be sung at sight and repeated a few times until absolute accuracy of notes and rests has been acquired. The above is a specimen of exercises for beginners, the conductor indicating each beat with a baton, first quite slowly and afterwards at a quicker speed.

Such exercises should be invented by the choirmaster on each occasion, and not used over again, as they are intended to be preliminary to reading at sight. They should be sung to the sounds "ah" or "la," the broad vowel sound being generally preferable to a closer one.

Next, simple intervals may be introduced into the exercises; and now it must be decided whether *Tonic Sol-Fa* or *Staff* notation is to be taught. It is not proposed to enter here on a discussion of the merits of these rival systems. The choirmaster will probably have a predilection for one or other. The Tonic Sol-Fa is undoubtedly the simpler, and is said to give the best results with pupils of limited intelligence. Staff notation, on the other hand, renders a vastly larger repertoire of music available to its disciples.

Until the choir has attained considerable facility in singing simple diatonic intervals, no attempt should be made to introduce words. The syllables Do, Re, Mi, Fa, Sol, La, Ti (or the Tonic Sol-Fa equivalents) can be used for the degrees of the scale.

Exercises. The next stage should be the introduction of simple two-part exercises, which the choirmaster may either invent for himself or else obtain from one of the many collections published for the purpose. Both parts should be practised separately, especially the seconds, before they are sung in combination. This remark applies even more forcibly with regard to the full practice, which should take place at least once a week; each single part must receive separate rehearsal before the *ensemble* is attempted.

We have now advanced to the stage when easy four-part anthems may be rehearsed. And here it may be as well to repeat the advice just given—until the music is fairly well known, no words should be sung, only the syllables representing the notes of the scale. The reason for this is obvious. We do not wish the attention of the singers to be divided between two entirely

different and almost equally difficult tasks, for the correct pronunciation of words in singing is frequently a source of much trouble, even to such choristers as have had a good education. The vowel-sounds in the North of England are often compounded in a fearful and wonderful manner; for that matter, London itself has some strange perversions of English pronunciation, such as the conversion of the long ā into ie, and so forth. It follows that exercises in the simple vowel-sounds will be required. A series of such sounds may be recited or sung to a monotone. For instance:

ā	â	ă	ē	ĕ	ī	ĭ	ō
May	ma	mat	neat	net	bite	bit	note

ŏ	ōū	ŏŭ	ŭ	ū	āū	ow	oy
not	boot	foot	but	tune	caught	now	boy

These comprise all the vowel sounds in the English language. Among the consonants that will require attention the letter R may be picked out, especially as a final, and before a vowel; indeed, almost all final consonants will show a tendency to be eluded, and the latter H will probably want some attention. Some attention, too, must be given to breathing. If not already marked, the teacher should indicate the places in the music where breath is to be taken, and see that it is done quickly, and above all, silently.

Blending the Parts. As regards *ensemble*, or the nice balancing of the parts one against the other, the members of the choir should be taught from the very first the necessity of listening to the other parts, and so endeavouring to make their own efforts blend with the others. They must not consider their own part as the most important, unless it is solo work they are doing, but should try to sink their own individuality for the benefit of the choir as a whole.

PAUL CORDER

Varieties of Sugar. Cultivation of the Cane. Separation of the Juice. Clarification. Concentration. Evaporation and Crystallisation. Curing.

CANE SUGAR & ITS MANUFACTURE

ORIGINALLY regarded as a medicinal confection, sugar has become one of the most important foods of the human race. The world's production is estimated at from 15 to 20 million tons, and the consumption of sugar per head of the population in the United Kingdom is over 95 lb. per annum. Chemically, sugar is classed with the carbohydrates, and the various kinds of sugar may thus be divided :

1. Saccharose, or cane sugar ;
2. Lactose, or milk sugar ;
3. Glucose, or grape sugar ;
4. Levulose, or fruit sugar ;
5. Maltose, or malt sugar.

Saccharose. Saccharose, the most important sugar, is very widely distributed throughout the vegetable kingdom. The chief sources are the sugar cane, the sugar beet, palm, maple, sorghum, and maize, the first two yielding the bulk of the sugar supply. Sugar is a crystalline solid, freely soluble in water, a cold, saturated solution containing over 65 per cent. of sugar, while as much as 82 per cent. of sugar can be taken up in a boiling solution. If a strong solution of sugar be slowly evaporated, crystals are obtained, which, if allowed to deposit on string, form *sugar candy*. When sugar is heated it melts, and if then allowed to stand till cold yields what is known as *barley sugar*. By combining butter and flavouring matter with melted sugar the familiar *butterscotch* is produced. If strongly heated, sugar darkens and gives a coloured product known as *burnt sugar*, or *caramel*. Sugar is the source of alcohol in wines and beer, although cane sugar is not itself directly fermentable, but has to go through an intermediate stage before being acted upon by yeast. The question is often asked : What is the difference between beet and cane sugar ? The answer is that sugars from any source are indistinguishable if equally purified.

There is a slight difference in the amount of ash yielded by the two, and also a chemical difference in the constituents of the ash.

Lactose. This is also known as milk sugar, as it is the only carbohydrate of importance in milk. Milk sugar is not so sweet as cane sugar, and is only soluble to the extent of one part in six of cold water. When fermented with certain yeasts, milk sugar yields the drink called *koumiss*. Large quantities of lactose are used as a food for infants and invalids, and a smaller proportion is employed in the preparation of medicines.

Glucose. Other names for this are *dextrose* or starch sugar. It exists in grapes and honey, but is made on a manufacturing scale by acting on starch with a dilute acid. Liquid glucose, or *starch syrup*, as well as solid glucose, is produced, and the residue from the manufacture, known as *climax sugar*, is used by brewers for colouring porter. Glucose dissolves in water, but it is only about half as sweet as cane sugar. It is readily fermentable, and yields 48·67 per cent. of alcohol. The chief uses of glucose are in the brewing of beer, the manufacture of confectionery and jams, and in calico-printing.

Levulose. This exists in honey and ripe fruits, but is made commercially by the action of weak acids on sugar solution, the product being known as *invert sugar*. Pure levulose can be obtained from inulin, the starch contained in the dahlia, inula, and chicory. It is sweeter than saccharose, and very soluble in water. Invert sugar is of considerable importance in brewing.

Maltose. Malt sugar is formed by the action of malt extract on starch, and yields, when fermented, 50 per cent. of its weight of alcohol. By boiling with dilute acids it is converted into glucose; it is always present in commercial glucose.

Cane Sugar. The sugar cane which yields this sugar is a huge grass with a knotty stem. It belongs to the natural order *Graminaceæ*, and is known botanically as *Saccharum officinarum*.

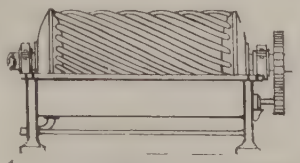
By cultivation many varieties have been produced, the principal ones being the Mauritius, the Laina, the Otaheite, the Bourbon, the Ribbon, the Java, the China, the Singapore, the Indian, and Cristalline. Some of these are probably distinct species, such as the China sugar cane ; the others differ from each other in the colour and hairiness of the stem. Some varieties are preferred in certain situations, the Cristalline cane, for example, having a reputation as a disease-resister in the French West Indies. The Bourbon cane was originally introduced into the West Indies from the Isle of Bourbon. The varieties most in request are long-jointed canes, the leaves from which are readily detached from the stem as they die. As a rule, however, it may be taken for granted that each country has produced a special variety of cane suited to its climate and soil.

The sugar cane grows in a wide range of climatic conditions, but flourishes best in high latitudes, on account of the greater length of the days, and attains its greatest perfection within the tropics. Light is essential to the storage of sugar by plants, the erect habit of the sugar cane having an important influence in obtaining the maximum of sunlight.

What the Cane is Like. The sugar cane is perennial, and produces a stem 8 ft. to 12 ft. high and 1 in. to 2 in. thick, while there are from 40 to 80 joints. The leaves are produced at the joints, and are 4 ft to 5 ft. long and 2 in. wide. As the canes grow, the lower leaves dry up, fall off, and are removed, the process being known as *trashing*. The sugar cane needs a fertile soil, clay and sandy soils being unsuitable. In French Guiana the only remunerative cultivation of the sugar cane is on low lands that are periodically manured by flooding with water from which black mud is deposited. In Queensland, land of virgin soil is prepared by light ploughing to get rid of grass. The ground is then ploughed 9 in. to 10 in. deep, and worked with the harrow and roller to ensure sufficient soft mould for the plant.

Propagation. The sugar cane is propagated from cuttings or seed, but usually by the former method, seed being only used for obtaining new varieties. The cuttings may be either from the top

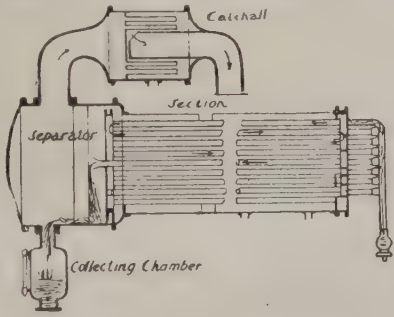
or from the body of the cane, and experimental work in the Mauritius seems to indicate that the tops are preferable. If *tops* be used, the leaves should be stripped from two or three buds, so that they can come into immediate contact with the soil. If *plant canes* be used, they should be cut into lengths of three buds each, care being taken not to injure the buds. The plants are then placed in drills at a distance of about 3 ft. from centre to centre. The canes are placed horizontally, and with the buds pointing one way; 1 in. to 1½ in. of mould above the cutting is quite sufficient, since it will grow more rapidly than if planted deeper. After a few days, according to the weather, rootlets will spring from the joint surrounding the bud, and in from ten to twenty-one days the buds will begin to appear above the ground.



1. THE WETZEL EVAPORATOR

Cultivation. All the cultivation afterwards required will be to keep the ground open and clear of weeds as long as the horse-hoe can be used, after which the ground can be left until crushing season. Cutting of the cane is effected in several ways—some are cut with a knife, the cane being trimmed and topped while in the hand, while others are cut with a sharp hoe, the trimming and topping being done by another group of labourers. When the cane is light upon the ground, or stands erect, the former mode seems preferable, but where the crop is very heavy the latter method is used. In either case care should be taken to cut the cane close to the ground, as the *ratoon* (the cane which springs up from the stump) will rise from the highest bud on the cane root left; and if this be not below the surface, support against the wind for the young cane will be lacking. The practice of different plantations varies in regard to replanting or growing from ratoons, for although cane will retain and yield crops for several years without replanting, ratoon crops are not so heavy as those of plant cane.

Manures. We now come to consider the various manures that are necessary. Phosphatic manures give considerable and very remunerative increase when used together with manures containing nitrogen and potash. Phosphate slag seems to be an excellent source of phosphorus for cane plantations, and ought to replace superphosphate. Nitrogen, in the form of sulphate of ammonia, nitrate of soda, and dried blood, shows a favourable influence on the yield. The best results obtained by the authorities of the Botanical Gardens of British Guiana were obtained with a mixture of one-third nitrate of soda and two-thirds sulphate of ammonia, although for large quantities sulphate of ammonia gives a better pecuniary result. The whole object of manuring is to supply to the plant those chemical constituents in which the soil is deficient.



2. THE YARYAN EVAPORATOR

Diseases of the Cane. The cane is subject to a variety of animal and vegetable pests. In the first category are included rats. These are kept down by poison or the use of the Liverpool virus. Among insects the moth-borer is prevalent, and is only got rid of by systematically collecting the moth and destroying the diseased canes by fire. Several other borers are known, some of the pests making special attacks on the roots of the cane. Spraying with paraffin emulsion is recommended for destroying some of the small insects. Vegetable or fungoid pests, such as red smut, top rot, sereh, ananas, and gumming disease, attack the leaf and stem. The remedies are to choose canes known to be disease-resistant, to correct errors of cultivation, and to destroy all affected canes by burning. Rotation of crops and green manuring are also a means of combating fungoid diseases.

Harvesting. The ripe canes are cut with hatchets, close to the ground. The top joint is discarded, and all the leaves are stripped off. Damaged canes are separated, and the cut canes tied in bundles for conveyance to the factory by wire tramways or other means. The weight of crop varies very much, from 70 to 80 tons having been taken from rich scrub-lands in North Queensland. A fair average is 25 to 40 tons per acre, and with modern appliances and methods a ton of sugar is sometimes made from little more than ten tons of cane. There is 16 to 18 per cent. of sugar present in the sugar cane, and about 70 per cent. of water. The sugar is distributed irregularly throughout the cane, the joints and the lower end being poorer in sugar than the higher parts.

Processes of Manufacture. The sugar cane is passed through a sugar mill, and the juice that is expressed is submitted to processes of purification. The juice is concentrated until the sugar is obtained in a crystalline form. The sugar is then prepared for the market, or "cured," and the molasses treated so as to recover from it any remaining sugar. These processes are conveniently considered in the following divisions:

1. Separation or extraction of the juice.
2. Clarification and defecation of the juice.
3. Concentrating and crystallising.
4. Curing or cleansing the sugar.

Separation of the Juice. The cut canes are passed through a mill, which squeezes out the juice. The oldest form of cane mill was provided with wooden or stone rollers, but, except in some parts of India, these have been replaced by iron mills. The three-roller mill is the most used. In this, one roller, the "head" roller, is placed above the other two, and moves in the opposite direction to them. The mill is so arranged that the cane can enter easily, the pressure being increased by the adjustment of the rollers. In Stewart's cane mill additional power is obtained by means of a massive crushing head forced down by hydraulic pressure. Merrilees, Watson & Co. dispense with the use of hydraulic appliances, and make a mill with yielding ends, by means of *toggle* levers acted on by springs.

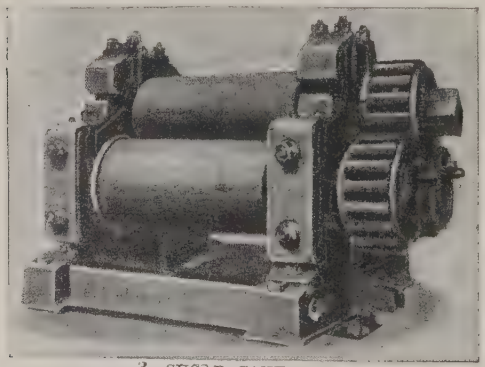
The mill automatically relieves the pressure on one or more rollers, and prevents jamming in case of irregular feeding. Simpler forms of mill have but two rollers [3], and others are used having rollers up to eight in number. The mills are often

fed mechanically. As the crushing mill does not press out the whole of the juice, double and triple crushing is employed, and sometimes the crushed cane is soaked with hot water in its passage from one mill to the other. It is not possible to extract the whole of the sugar, but the loss is reduced to about 1 per cent. Other methods embody the use of a diffusion process—a soaking in hot water in closed vessels—between the two crushings. The *bagasse* (crushed cane) from the first mill is passed into diffusers containing heated water, and after a time the bagasse is drained from the saccharine liquid, and pressed in the second mill. The weak liquid from the diffusers is re-heated and used in the diffusers for fresh bagasse. The diffusion process is universally used in making sugar from beet, and is fully described later.

Preparing the Cane. Various methods have been suggested for preparing the sugar cane for the mill, such as shredding and cutting up the cane. The Ross apparatus cuts the cane into four-inch lengths; then slices the pieces and passes them on to the mill. The Fletcher machine, for a similar purpose, was patented in 1894, and can be regulated to secure a product of the desired degree of fineness. These machines are suitable for preparing cane for the diffusion process.

The cane juice is next strained through a series of wire-gauze screens to remove pieces of cane and other mechanical impurities.

Clarification. The strained juice is then submitted to the *clarification*, or *defecation*, process. The juice is run into a large copper vessel heated by steam, and raised to a temperature of 130° F. Milk of lime, in the average proportion of 4 oz. of quicklime to a gallon of juice, is then added, and the heat continued until a temperature of 180° F. is reached. At this temperature a thick scum rises; and when the scum shows signs of "cracking" the steam is turned off. The juice is allowed to rest, and the intermediate layer of clear juice drawn off into an evaporating apparatus. The scum and sediment are transferred to a separate tank. The lime is used to neutralise the natural acids of the



3. SUGAR CANE MILL
(A. & W. Smith & Co., Ltd., Glasgow)

juice, which, if allowed to remain for any length of time, would cause inversion of the sugar.

The heat removes the albuminous matters by causing coagulation, and the lime assists mechanically and chemically in removing the coagulated albumin as scum or sediment. The process of adding lime is called *tempering*; and as the quantity to be added varies, the lime is added until a faint alkaline reaction is indicated by means of litmus paper. Various modifications of the lime process are practised, with the object of producing a whiter sugar — lime bisulphite, sulphurous acid, and "Newlanite" (phosphoric acid absorbed by kieselguhr). It is at this stage that special treatment results in the production of the yellow crystals known as *Demerara*, the procedure being really very careful tempering, combined with the addition of sulphuric acid. A tin-salt is sometimes used for the purpose, but its use should be discouraged. Aniline dyes are also inadmissible.

Continuous Defecation. Of late years continuous methods of defecation have been devised. Harvey's apparatus is a trough-like vessel heated by steam. Adjustable baffle plates or transverse divisions are fitted at spaced distances within the defecating vessel, forming practically separate chambers, while a settling chamber is fitted at the end of the defecator. Channels are arranged to draw away the scum and clear juice. By adjusting the temperature a continuous movement is given to the liquid, which readily parts with suspended matter in the settling chamber. In Deeming's superheat clarification method the juice is heated in successive stages to a high temperature, and is thence passed to a special form of settling tank. This tank is a large cylinder with a conical bottom, and inside this is a tapering vessel that reaches down to the conical part of the cylinder. The hot juice is conducted into the outer tank, and causes currents of juice which induce the sediment to fall into the conical bottom of the cylinder, the clear liquid being drawn off at the top.

The scums which have been yielded by the defecation process have steam blown into them, still further to coagulate the albuminous matter, and are then filtered, lime being sometimes added to assist the process.

Carbonatation. An alternate process of clarifying cane juice is known as *carbonatation*. The method is always used in beet sugar manufacture, and is described at a later stage. The advantage claimed for the process in the case of cane sugar is that the resulting produce is purer and fetches a higher price than sugar submitted to the usual defecation process.

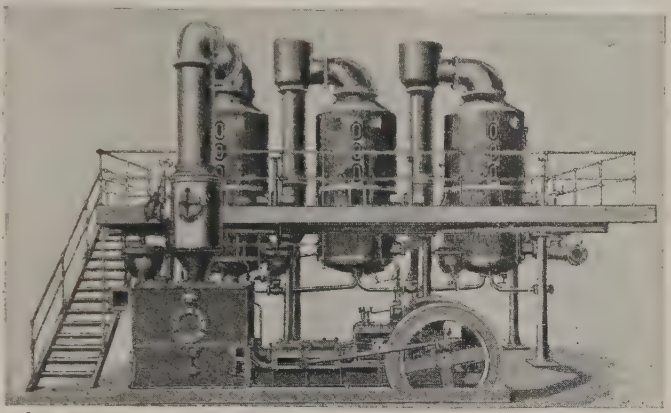
Concentrating. The next step in the manufacture of sugar is to remove the water from the clarified juice so that the sugar may be obtained in a solid state. Usually this is done by evaporating the liquid until it reaches the syrup stage, when it is transferred to a vacuum pan, and concentrated until only 5 or 6 per cent. of water is left in the mass. The oldest method of evaporating the water from the sugar is effected by using a series of pans known as the *copper wall*, consisting of a series of open pans called *teaches*, or *taches*, placed over a flue.

The open fire has now been replaced by steam-pipes in the pans. This led to what are called *film evaporators*, or *wetzels*, which expose a thin film of liquid to the action of heat. The earlier patterns consisted of a cylinder heated by steam, revolving in a trough of sugar juice. This gave place to the Wetzel evaporator [1], in which the cylinder was replaced by a number of copper pipes. The steam passes through the pipes from one end to the other the apparatus revolving in a trough of juice.

The Concretor. Fryer's concretor is a more economical method of applying heat to the evaporation of water. The object in the concretor is to pass a shallow stream of juice over a series of trays heated by an open fire or steam. The trays are divided by ribs running from one side

nearly to the other, so that the liquid requires to take a narrow, winding course during its passage from one end of the apparatus to the other. One of the concretors consists of a series of ten trays, measuring about 48 ft.; and with the serpentine course which the juice must needs take, five or six times this length is traversed, and this in about five minutes. On leaving the last tray the juice is run into a trough with a revolving cylinder heated in its interior by hot air. The heating in this part of the apparatus is continued until the mass becomes flaky instead of liquid, when it is discharged into casks, where it solidifies, and is ready for the refiner. The whole process takes about half an hour, and the average yield of concrete is about 2 lb. to the gallon of juice.

Evaporation Under Reduced Pressure. Howard, in 1813, patented a method of evaporating sugar by what are known as *vacuum pans*, which it will be convenient to refer to here. He found that by reducing the atmospheric pressure by pumping out the air from a covered pan, solutions of sugar boil at a much lower temperature, and thus no risks were run of injuring the sugar by over-heating. Further, the process was more rapid, as, owing to the lowering of the boiling-point of the liquid, the difference in temperature between the heating steam and the boiling liquid is greater, and hence greater transmission of heat is obtained for a given heating surface. The heating of Howard's vacuum pan was effected by means of a steam-jacket, but this was afterwards replaced by steam-coils within the pan. Roth introduced the use of steam-pipes, and Degrand endeavoured to utilise the vapours of the pan for heating a further quantity of liquid.



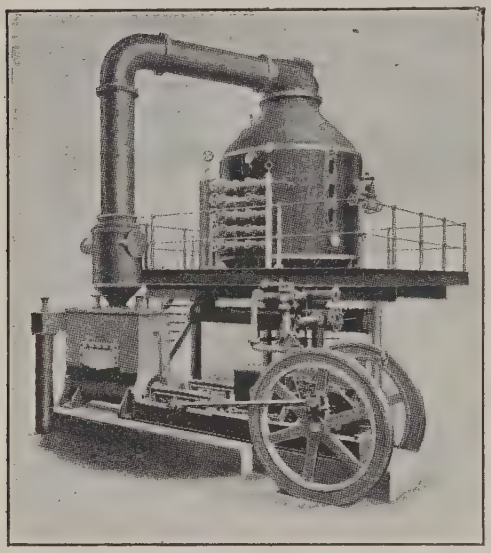
4. TRIPLE EFFET APPARATUS (Harvey Engineering Co., Ltd., Glasgow)

Multiple Evaporation. This plan of Degrand's was further developed by Rillieux, who designed a series of three vacuum pans, which he called *triple effet* [4]. The vessels are connected by means of valves, so that the juice can be drawn successively from one to the other, but the most important principle is that involved in using the latent heat of steam three times over. Dr. J. Lewkowitch explains the principle of the multiple effet as follows: "Suppose," he said, "we have at our disposal heating steam of what is termed in practice *half an atmosphere* (or one and a half atmospheres expressed in absolute pressure), such as the exhaust steam from an engine. The temperature of such steam would be about 112° C. Suppose, further, that we have employed the best practical means for producing vacuum at the outlet of the third vessel, so that the temperature would be about 46° C. We have, therefore, a temperature difference of $112° - 46° = 66°$ C. available for evaporating purposes. This difference would have to be distributed over the three vacuum vessels or effets. If we make the heating surface of each vessel the same, it follows that the amount of water evaporated will be the same in each vessel. Consequently, the difference of temperature in the three vessels must be the same—$66 \div 3 = 22°$ C. We have now the following state of affairs: the steam entering the first effet has a temperature of 112° C. We require 22° C. for raising the liquor in the first vessel to the boiling-point; the liquor would then have a temperature of $112° - 22° = 90°$ C., and the vapours escaping from the outlet the same temperature of 90° C. To this temperature of the vapour corresponds the absolute pressure of 525 mm., or, in technical parlance, a vacuum of 235 mm.—say, 9 in. A gauge (*manometer*) fixed to the outlet of the first vessel would therefore register this vacuum. The steam enters the heating system of the second effet with a temperature of 90° C. The liquid in the second vessel requires 22° for raising it to the boiling-point, and has therefore the temperature of 68° C. If no loss of heat takes place, the temperature must be slightly higher, as the flow of liquid goes in the direction from the first effet to the second effet, and the liquid coming from the first vessel has the temperature of 90° C., but this point may be neglected here. The vapour escaping from this second vessel will have the temperature of 68° C., which corresponds to an absolute pressure of 213 mm. (8·5 in.) or a vacuum of 547 mm.—say, 21·5 in. This vapour of 68° C. enters the heating chest of the third vessel, and brings the liquid therein to the temperature of 46° C."

The Yaryan Evaporator. Rillieux, the inventor of the system of multiple evaporation, employed horizontal cylinders furnished with a number of horizontal tubes. A disadvantage is that the steam passes through all the heating tubes with a uniform velocity, very low in the case of the second and third effets, thus making a rapid exchange of heat impossible. This led to the use of vertical vessels with shorter horizontal heating tubes, such as are now employed. The next innovation was Yaryan's, in which the liquid is passed through narrow tubes while the steam circulates around them. Yaryan adopts in his apparatus [2] the two principles of evaporation in *vacuo* and multiple effet. The evaporator consists of a series of straight tubes passing from end to end of a shell or drum, and coupled together by an ingenious arrangement of pockets to form coils, the main advantage gained being the ease with which the straight tubes can be examined and cleaned.

Lille's Evaporator. This apparatus introduced in 1893, has for its object the separation of suspended liquid particles from the vapours evolved during the evaporation of liquids. By means of perforated plates the juice is distributed over a series of horizontal pipes arranged in a

closed chamber. Steam is circulated through the pipes. The vapour from the juice passes through and around baffle plates into a prolongation of the evaporating chamber called the subsiding chamber. The baffle plates cause the suspended particles to separate and fall to the bottom of the subsiding chamber, whence they are drawn off by means of a pipe below. The vapour passes off by an outlet



5. THE VACUUM PAN
(A. and P. W. McOnie, Glasgow)

pipe in a dry state, the pipe being in the upper part of the subsiding chamber.

Harvey's Evaporators. Patented in 1899, these evaporators are constructed of a series of steam-pipes with vertical juice-circulating tubes and vapour-generating vessels which are superposed in vertical columns so as to act as triple or multiple effet. Rapid circulation of the juice is attained, and a quick rate of evaporation.

There are numerous other varieties of evaporator, but each will be found to fall within one of the general kinds enumerated above.

Crystallising. In the copper wall, Wetzel apparatus, and Fryer's concretor, the juice is converted into solid sugar, while in the multiple effet and Yaryan evaporator the juice is only reduced to a syrupy consistence—until it has lost 70 per cent. of its bulk. When the juice has reached this stage it is transferred to a *vacuum pan* and boiled until grains of sugar are formed. The vacuum pan [5] is fitted with two or three coils [6] of steam-pipe sufficiently separated to allow of free circulation of the contents of the pan. The pan is fitted with pumps for making a vacuum, and a contrivance called a *proof-stick* for obtaining samples of liquid from the interior without breaking the vacuum. The working of the vacuum pan is as follows: The air-pump is started, and as soon as the vacuum reaches 26 in. or 27 in. the feed cock on the side of the pan is opened, and sufficient liquor drawn in to cover the bottom coil. Steam is then turned into the coil, and the liquor rapidly evaporates. Further supplies of liquid are admitted at short intervals, the feed cock being opened for about fifteen seconds at a time until the contents of the pan show signs of "graining," when samples are taken with the proof-stick. The grain is "fed" carefully, the cock being opened frequently, and each time the quantity admitted increased. As the amount of syrup in the pan increases, steam is turned on in the other coils, until at the completion of the charge the pan is nearly full, or up to the "bull's eye" or sight-hole in the side of the pan. In this way the grain "grows" in size. The whole skill of the pan-boiler consists in inducing the grains to grow to their utmost, and this can only be done very slowly and by manipulating the temperature.

Striking the Pan. The mass in the pan at the finish of the boiling is termed *massecuite*, and the operation of discharging or emptying the pan is known as *striking*. The striking-point is judged by the firmness of a sample taken from the pan and suddenly cooled in water. When the grain is very small the pan is sometimes only half emptied, and fresh syrup admitted, the half-emptying process being known as *doubling*, and the discharged massecuite as *first cut*. The process with pure juices can be repeated several times, but a point is reached at last when the crystals do not increase in size, and the whole charge is *struck*. To save time in boiling it is now general to add sugar grains to the pan instead of forming grain from the syrup, this being known as *seeding*. In a pan containing about thirty tons of massecuite, one ton of sugar is required, the sugar used being that recovered from the molasses.

Curing the Sugar. The massecuite from the last operation consists of a mixture of crystalline sugar and molasses. The problem now is to separate the two. The oldest method is to run the massecuite into coolers, and, when set, to dig out the mass and put it into casks with perforated bottoms. In this way the molasses is drained out partially and yields raw or *muscovado sugar*. This crude method has been replaced in most countries by treatment of the massecuite in centrifugals. This process and crystallisation in motion which now accompanies it is dealt with later in connection with refining.

The recovery of sugar from molasses is dealt with after a consideration of beet sugar, as the processes are common to the manufacture of cane and beet sugar.

6. LYRE-SHAPED TUBES IN VACUUM PAN

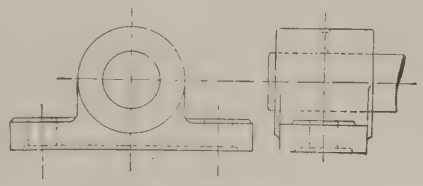
Cane Sugar Factory. A factory capable of dealing with 100 tons of cane per twenty-four hours, and employing engines of 150 h.-p., turning out eight tons of sugar daily, could be erected and equipped for about £40,000. The cane mills are placed on the ground floor, and the juice is pumped up to the top floor, and descends as it is manufactured. In the laboratory a *polariscope* and a balance are required, as well as dishes and other pieces of apparatus. The establishment of central factories has been urged as a means of assisting the sugar industry in the West Indies. A factory in which modern machinery and scientific control are installed would be able to obtain a better yield of sugar than smaller factories. In buying sugar cane the sugar-yield is the only satisfactory basis.

Technical Drawing. Deadeyes. Adjustable Bearings.
Waggon Axle-boxes. Babbitt Bearings. Brackets. Hangers.

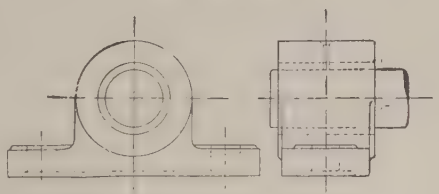
BEARINGS AND AXLE-BOXES

Bearings. The simplest form of bearing for a shaft journal is illustrated in **55**, and consists of a metal boss having a foot cast with it for convenience of bolting down ; such a bearing is termed a "deadeye." It is chiefly used for slowly revolving shafts of hand-driven appliances ; when wear takes place it is necessary to renew the bearing itself. Fig. **56** shows a similar deadeye fitted with a renewable gun-metal sleeve, or bush, which is forced into place, and can be replaced when worn. Alternatively, such plain or bushed bosses may be designed as part of a machine framing instead of being separate pieces. A great drawback to the use of these bearings is the necessity for parallel shafts, and the inconvenience of removing all objects keyed thereon in order to get the shaft out of the bearings, for it must obviously be moved endwise.

Divided Bearings. The divided brass and adjustable cap are illustrated in **58**. They have not only the advantage of being renewable, but by taking off the cap piece and one half of the brass the shaft may be removed bodily ; the bearing is also adjustable by the tightening of the cap bolts and the consequent closing of the brasses when wear has taken place. The cap is secured by studs and lock nuts ; the brass has pegs cast on it which enter corresponding holes in the cap and seating in order to prevent turning ; flanges are provided at each end to take the thrust of collars, etc., on the shaft. These bearings may be arranged as part of a machine frame or alternatively as a separate article. Fig. **57** indicates it in this latter form, when it is termed a *plummer block, or pedestal ;* the cap bolts pass through the block, and have square heads fitting in square holes ; the base of the block has facing strips provided, which facilitate the fitting of the pedestal in its place.



55. DEADEYE



56. DEADEYE WITH BUSH

The proportions for **57** and **58** may be taken as follow :

Thickness of brass	$B = \cdot 1A + \cdot 15$ in.
Thickness of flange	$C = B$
Length of turned portion	$D = 1 \cdot 7\ B$
Diameter of peg	$E = B + \frac{1}{4}$ in.
Thickness of cap	$F = \cdot 4\ A$
Thickness of cap	$G = \cdot 38\ A$
Centres of cap bolts	$H = 1 \cdot 8\ A$
Diameter of cap bolts	$I = \cdot 25\ A + \frac{1}{4}$ in.
Height of block above centre	$J = \cdot 4\ A$
Height of block base to centre	$K = 1 \cdot 5\ A$
Thickness of base	$L = \cdot 38\ A$
Centres of base bolts	$M = 2 \cdot 75\ A + 4$in.
Diameter of base bolts	$N = \cdot 25\ A + \frac{1}{4}$ in.
Length of base	$O = 3 \cdot 5\ A + 5$ in.
Length of bearing	$P = 1 \cdot 75\ A$

The brasses need not necessarily be circular in outside formation ; in fact, many of the earlier types of bearings had hexagon-shaped exteriors. A good form is shown in **59**, where the brass is square on the outside, and fits into a square block, the cap being made of mild steel ; the whole bearing is bolted to the steel side-frame of a heavy steam crab. This example is taken from an actual working drawing.

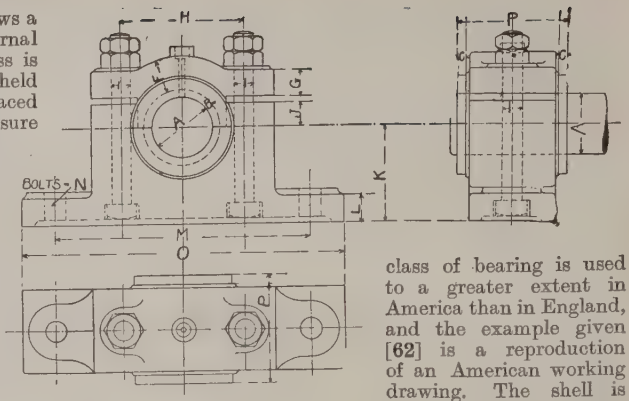
Adjustable Swivel Bearings. A modern form of bearing used largely for line shafting is illustrated in **60**. It consists of a cast-iron bearing divided on the centre line and held together by square threaded screws at the top and bottom ; the ends of these screws have concave heads which fit over corresponding convex projections on the central part of the bearing. The bearing is thus free to swivel radially, and at the same time can be adjusted in a vertical sense by means of the screws which can be rotated with a bar inserted in the holes of their bosses. The screws can be locked in position by set screws, as shown in the main bracket. The shape of the bracket varies considerably, according to requirements ; the one shown [**60**] is arranged for bolting up to a wall or column, but can easily be designed in the shape of the letter J, so as to bolt up to a ceiling joist or beam. The proportions may be taken as follow :

Length of bearing, if cast iron	$B = 4\ A$
Length of bearing, if brass	$B = 2\ A$
Distance between bosses	$C = A + \frac{1}{2}$ in. $\times 2 \cdot 75$
Depth of boss	$D = A + \frac{1}{2}$ in.
Diameter of boss	$E = A \times 1 \cdot 8$
Diameter of screw	$F = A$

Lubrication is effected by means of the two oil holes, which are fitted with lubricators ; sometimes an oil tray is suspended underneath the bearing to catch the waste oil. In the case of the shorter brass bearings the screw is made hollow, and lubrication is thus readily effected through the centre.

Railway Axle-boxes. Another type of bearing is the railway axle-box, which has several unique features not found in ordinary bearings. The brass does not embrace the whole circumference of the journal, nor does it extend the full length. The load always comes on the brass in a vertical sense, and there is therefore no necessity for a lower half brass, its place being taken by a device known as a "keep," which prevents undue vertical play between the journal and the brass. When a train is travelling at a high speed or passing round a curve there is considerable movement sideways, which must be allowed for in the axle-box, otherwise the continual side thrusts would destroy it. Lubrication is also a most important factor to be arranged for.

Waggon Axle-box. Fig. 61 shows a standard waggon axle-box having a journal $3\frac{3}{4}$ in. diameter by 8 in. long; the brass is $2\frac{1}{2}$ in. wide by $7\frac{7}{8}$ in. long. It is not held in place by fastenings, but is simply placed in a recess, and kept there by the pressure of the load transmitted to the journal. End movement of the brass is prevented by the shoulders formed upon the central portion. The axle keep is simply a $\frac{7}{8}$-in. diameter bolt. The top of the box is made with a rectangular recess for the reception of the bearing spring, which has a small clearance all round to allow for play. The whole box is guided in horn plates, and definite clearance is also allowed here. The chamber between the brass and the spring seat is filled with grease, which melts as the bearing becomes slightly warmed, and passes through the two holes which lead to the journal, and by such means a plentiful supply of lubricant is assured. A wooden shield is fitted to a shallow chamber at the inside end of the box in order to keep out dust and dirt. The views illustrated comprise a longitudinal section of the box and brass, showing the journal in external elevation, the dust shield and the grease door being also shown in section; a half transverse section, AA, through one of the oil holes shows the shoulder on the brass, which prevents its end movement; a half transverse section, BB, on the centre line; a half plan; a half sectional plan; and two views of the brass.

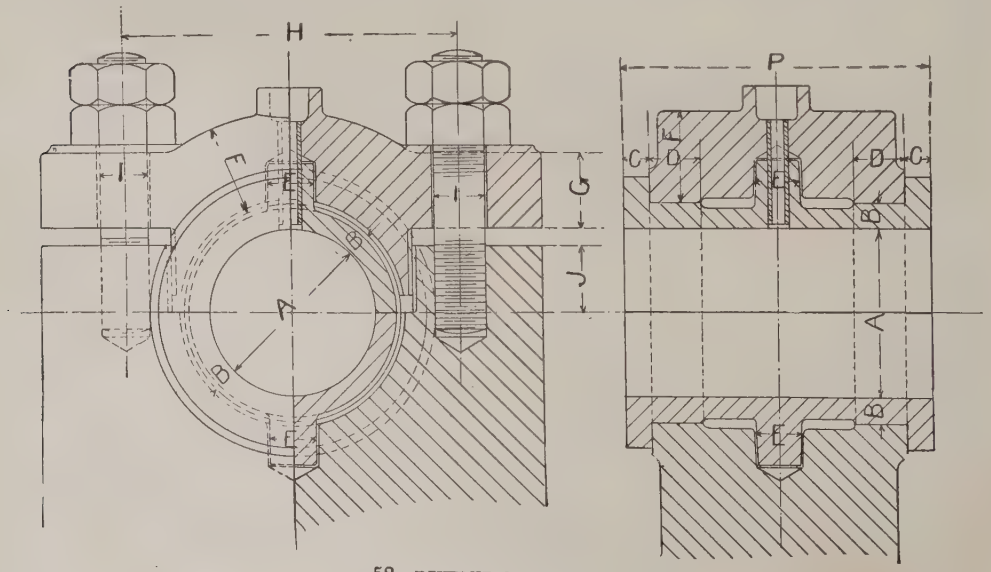


57. PLUMMER BLOCK

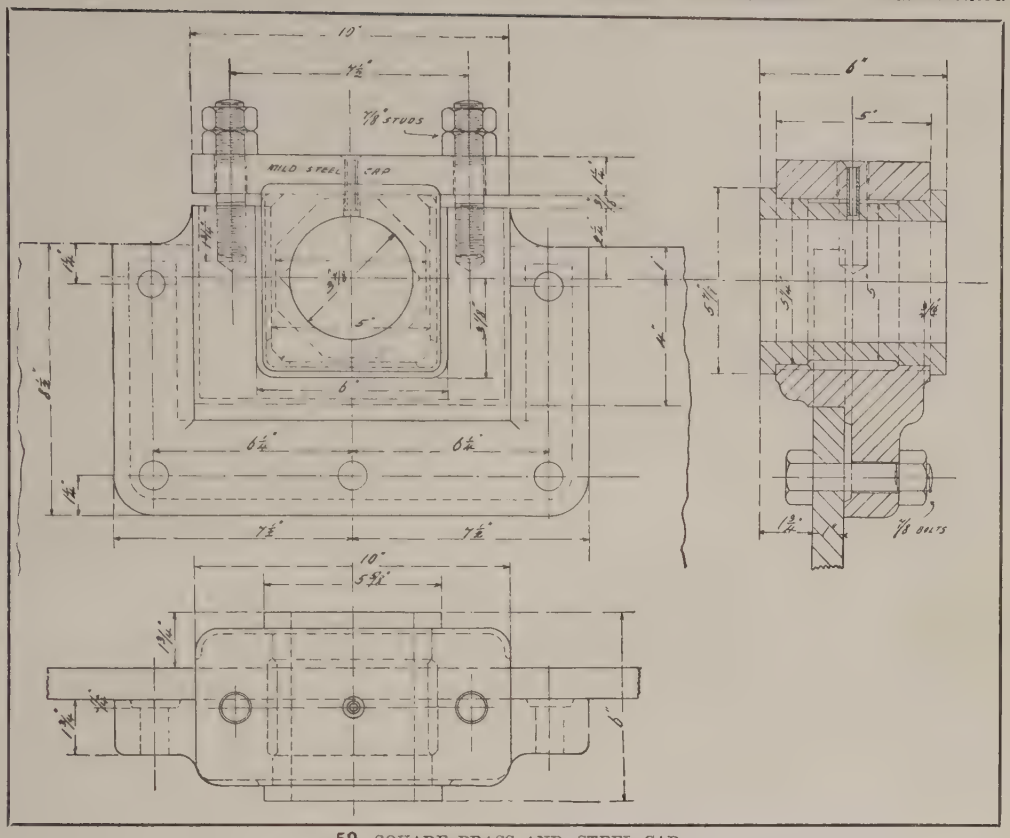
Carriage axle-boxes and those for locomotives differ in some details from the waggon boxes, but the general type is retained.

Babbitt Bearings. Brass and bronze are not the only metals which are used for bearings; various fusible alloys are also available, but are used as linings only, a removable shell being employed to carry them. Fig. 62 illustrates a shell lined with Babbitt metal, which is an alloy of tin, copper, and antimony; the shell may be either of brass or of cast iron, with recesses as shown to prevent movement of the lining; this class of bearing is used to a greater extent in America than in England, and the example given [62] is a reproduction of an American working drawing. The shell is somewhat thinner than an ordinary brass bearing, and is machined all over to bear its full length in the pedestal or seating block; it is prevented from turning by a peg or dowel fixed in the pedestal, and entering the lower half of the shell. The lining is readily renewed when worn away too much to afford proper support to the journal. Babbitt and similar metals melt at a low temperature, and can be poured like type metal; to renew a lining the old one is first melted out, then a dummy shaft or mandrel is placed in the shell, and new metal poured around it.

Brackets and Hangers. It is only in the building of a machine or engine that bearings are formed or fitted direct to framings, etc. For line shafting and for bearings on structural work it is usual to have a bracket between the bearing and its eventual support. Fig. 63 shows a plummer block fitted to a bracket, which has feet at right angles to the foot of the block, and is suitable for bolting to a wall or a column; the block might be cast in one piece with the bracket, but when made separately, as shown, it is readily adjustable horizontally and vertically; the bolt holes in the base of the pedestal are slotted, so that the block may be adjusted laterally; hardwood or steel



58. DIVIDED BEARING



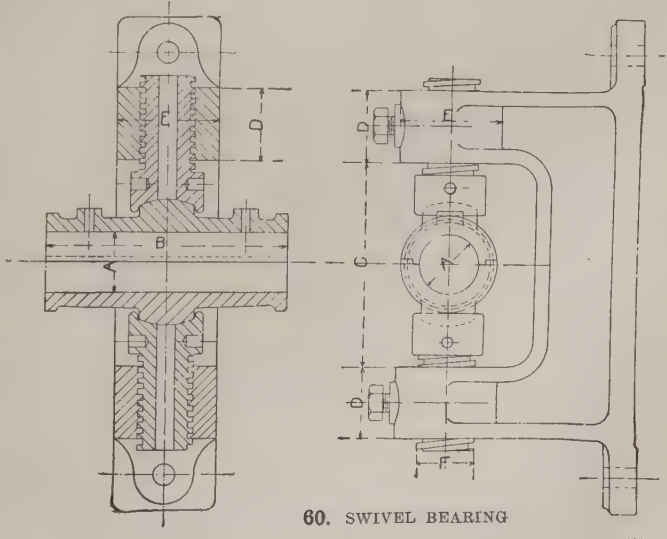
59. SQUARE BRASS AND STEEL CAP

wedges are then driven in at the ends. If vertical adjustments are required, a liner may be placed between the base of the pedestal and the bracket.

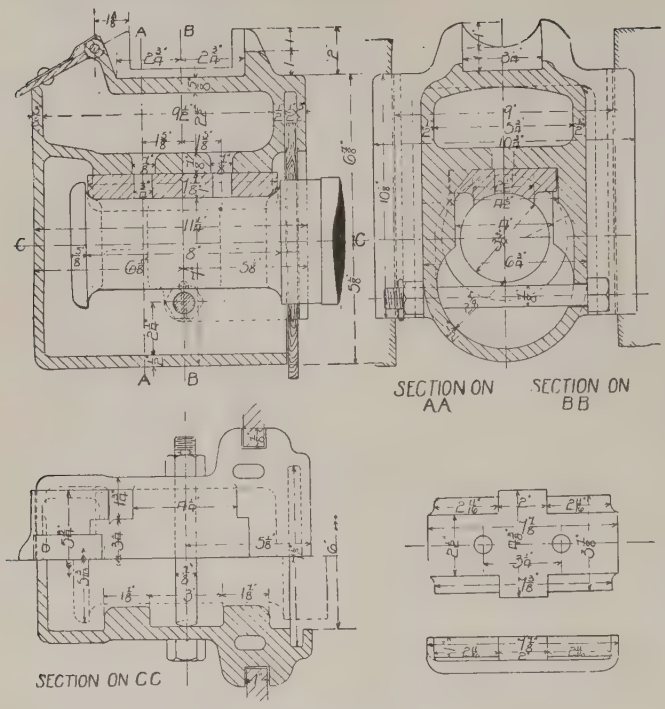
Fig. **71** illustrates a hanger suitable for suspending a pedestal from a ceiling or roof girder; the block is adjustable in the same manner as in the previous example. The dimensions of **63** and **71** are found by multiplying the figures given on the drawings by A + ½ in. where A = diameter of shaft; the over-all dimensions are, of course, modified to the local conditions.

There are many bearings which may be classed as special, such as footstep bearings, thrust bearings, roller bearings, ball bearings, heavy crank shaft bearings, etc.

Thrust Bearings. The most efficient thrust is that made with steel balls, for in such construction rolling friction takes the place of sliding friction. Fig. **64** illustrates a ball-thrust bearing arranged at the bottom end of a vertical spindle. This is made by the Hoffmann Manufacturing Co., Chelmsford. The construction is simple and entirely self-contained; the baseplate F can be made to suit any machine, or it may be part of a machine. The ball thrust proper is composed of an outer cast-iron casing, G, recessed into the baseplate, F; a cone or floating disc, H, which automatically adjusts itself in its seating and so ensures an equal load upon all the balls; a ring of balls held in a retaining cage, I, a hardened steel cup, K, and a retaining wire, L. The retaining cage I prevents any friction between the



60. SWIVEL BEARING



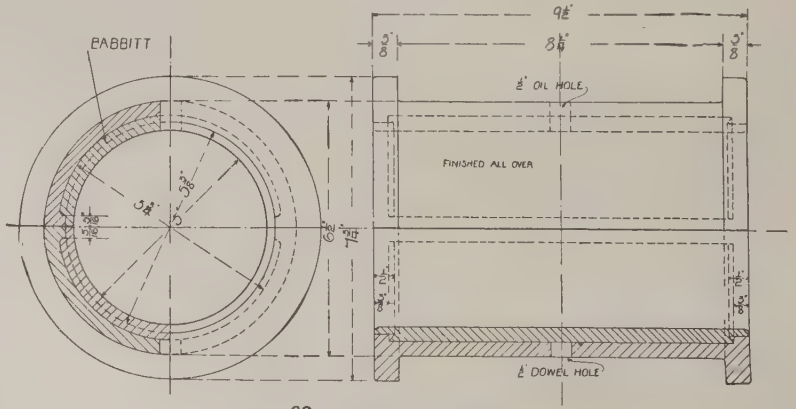
61. WAGGON AXLE-BOX

balls themselves; it is so designed as to float upon the balls, and therefore it does not bear upon either the cup K, the cone H, the casing G, or upon the spindle itself to cause friction. The retaining cage also enables the complete ring of balls to be handled without the balls falling out, a great convenience when putting a bearing together or dismantling. The retaining wire L keeps all the parts together. It is not necessary to key either the cone H or the cup K in place, as the friction between them and the balls is so slight that the friction between them and their seats is ample to prevent rotation. The steel balls are "Hoffmann balls," and are guaranteed to be within one ten-thousandth part of an inch of standard, both as to sphericity and size. These bearings do not provide for side support of the spindle, but only for end thrust; they are made in heavy, medium, and light types.

Footstep Bearing. An ordinary footstep bearing is shown in **66**, which provides for end thrust and also for side support of the spindle, but is not so efficient as the previous example. The thrust is taken upon a concave steel disc, A, laid upon the baseplate B, and kept from turning by the pin C; the disc A is kept in a central position by the gun-metal bush D, which bush also gives side support to the spindle; the set screw E keeps the bush from turning.

Ball-thrust Washers. A common device to take end thrust on light spindles is to have several washers arranged between the end bearing and a collar on the shaft. A better method is illustrated in **65**, which shows an application of two Hoffmann ball-thrust washers to the feed screw of a lathe slide. The ring of balls is held in a retaining cage, as in **64**; hardened steel washers are provided for the balls to run between; these bearings are made with a hole five-thousandths of an inch larger than standard, so as to allow the spindle to revolve freely inside the washer. The end of the spindle is screwed and fitted with a circular nut, which is kept from revolving by a pin which passes through both nut and spindle.

Ball-bearing Hubs. A good example of a ball bearing which takes both end pressure and journal pressure is shown in **68**. It is known as the Hoffmann patent *ball-bearing hub*, and is specially designed for motor-cars and vehicle wheels of all kinds. There are four rows of balls in each hub: the two outer rows take the journal load, while the two inner rows take end thrust in either direction. The load is taken in each case at right angles to the axis of rotation of the ball, and a perfect rolling action is attained with a consequent minimum of friction. The cone piece is of hardened steel ground out internally to a taper which fits the axle and is held on by a nut and pin in the usual manner. When this nut is removed, the wheel, with the bearing complete, can be taken off the axle. The removal of the wheel with bearing does not interfere in any way with the adjustment of the ball bearings. When it is required to dismantle the bearing, it is done

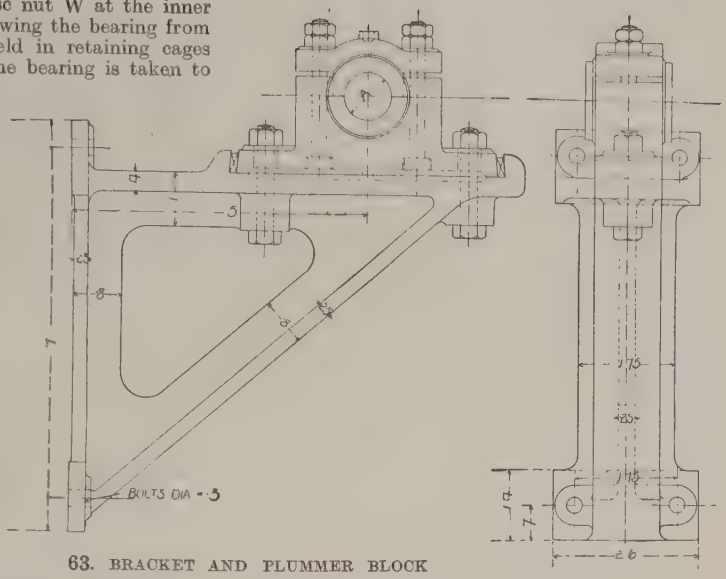


62. BABBITT BEARING

easily by unscrewing the disc nut W at the inner end of the hub, and withdrawing the bearing from that end. The balls are held in retaining cages and do not fall out when the bearing is taken to pieces. Leather washers are fitted to the disc nut in order to exclude dust.

The use of ball bearings as a means of reducing friction between moving parts has wide applications, apart from the examples given, but the principles of design and construction do not materially alter.

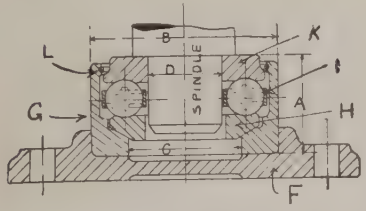
Roller Bearings. Another anti-friction appliance is the roller bearing, the underlying principle of which is identical with the ball bearing—that is, the substitution of rolling friction for sliding friction. Bearings are made having solid rollers interposed between the shaft and its seating; such bearings when properly designed are a great improvement on plain bearings having sliding friction, but they are not perfect. To obtain the best efficiency and the longest life out of a roller bearing the rollers must be flexible, so as to present even bearing surface along their entire length. The irregularities incidental to the running of shafting and axles prevent the uniform distribution of load over the full length of the bearing, resulting in unequal wear and distortion of the rollers when they are made solid, and consequently rigid. There are several methods of making rollers flexible, one of the best of which is adopted in the Hyatt *flexible roller*. This roller is made from a strip of steel wound into a coil or spring of uniform diameter; it is applicable to all speeds and loads, and can be made of thin material for light loads and high speeds, and of thicker material for heavy loads and slow speeds. The roller acts as an oil reservoir and the spiral grooves as oil carriers. If dirt or other foreign matter get into the bearing it is squeezed into the inside of the roller away from the bearing surfaces.



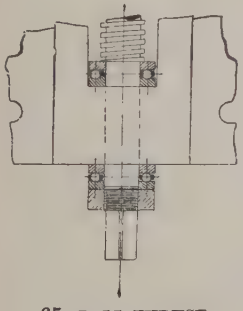
63. BRACKET AND PLUMMER BLOCK

Eccentric Bearing. Fig. 67 shows an application of the Hyatt flexible roller. It is a drawing of the eccentric bearing of a cotton gin. The bearing is not concentric with the shaft, but the centres are $\frac{3}{4}$ in. apart, which gives a reciprocal throw of $1\frac{1}{2}$ in. to the socket A. This movement is virtually a cam action, and is carried out at the high speed of 1000 revolutions per minute. The eccentric B has a split-steel sleeve fitted to it, this being ground to give a true and hard bearing surface for the rollers. A similar sleeve or lining is fitted inside the strap C. The rollers lie between the sleeves, and are kept in place by a retaining cage, which holds them in such a way as not to restrict their operation, but simply to prevent them from getting too far out of line. The split sleeves are shown in detail, and they are kept from turning by pins as indicated in the general views. The strap C is in halves to facilitate removal, and it has bronze end-plates fitted. The bearing is kept flooded with oil.

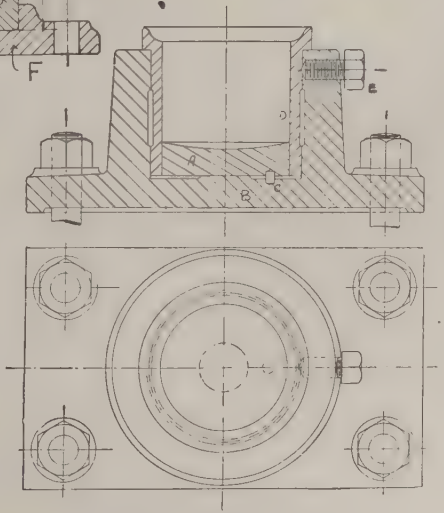
Waggon Bearing. A unique yet entirely successful application of the Hyatt roller is given in 69, which is a copy of a working drawing.



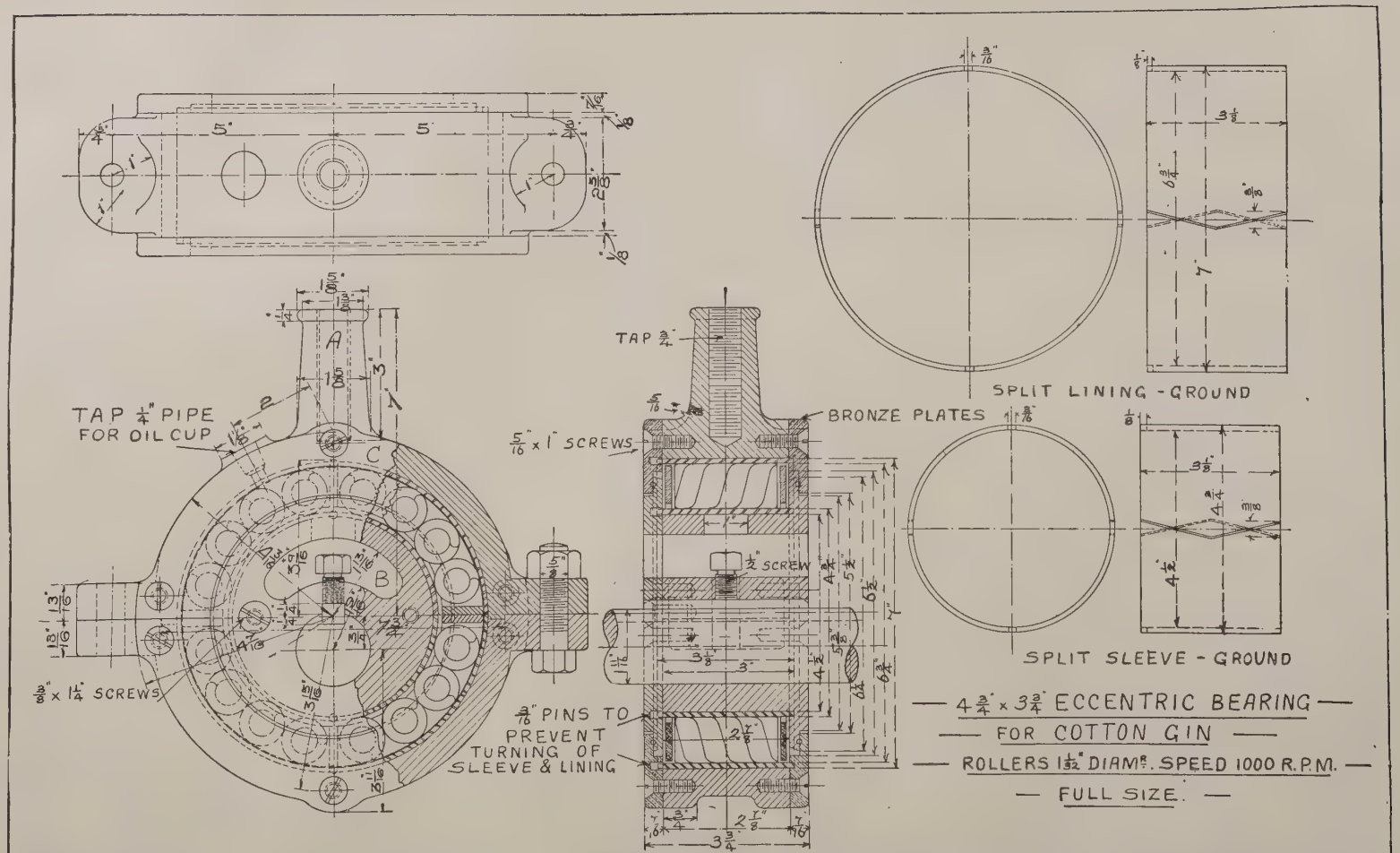
64. BALL-THRUST FOOTSTEP BEARING



65. BALL-THRUST WASHERS

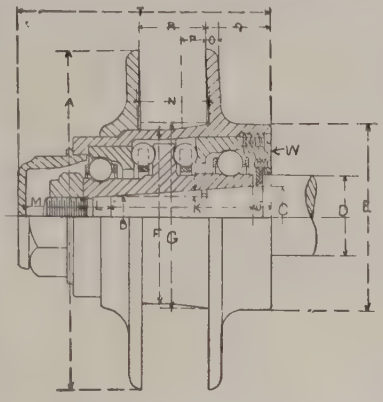


66. PLAIN FOOTSTEP BEARING


TAP ¼" PIPE FOR OIL CUP
⅝" x 1¼" SCREWS
TAP ¾"
5/16 x 1" SCREWS
BRONZE PLATES
½" SCREW
3/16" PINS TO PREVENT TURNING OF SLEEVE & LINING
SPLIT LINING - GROUND
SPLIT SLEEVE - GROUND
— 4 3/4" x 3 3/4" ECCENTRIC BEARING —
— FOR COTTON GIN —
— ROLLERS 1 1/32" DIAMS. SPEED 1000 R.P.M. —
— FULL SIZE. —

67. ECCENTRIC ROLLER BEARING (Hyatt Roller Bearing Co., Ltd.)

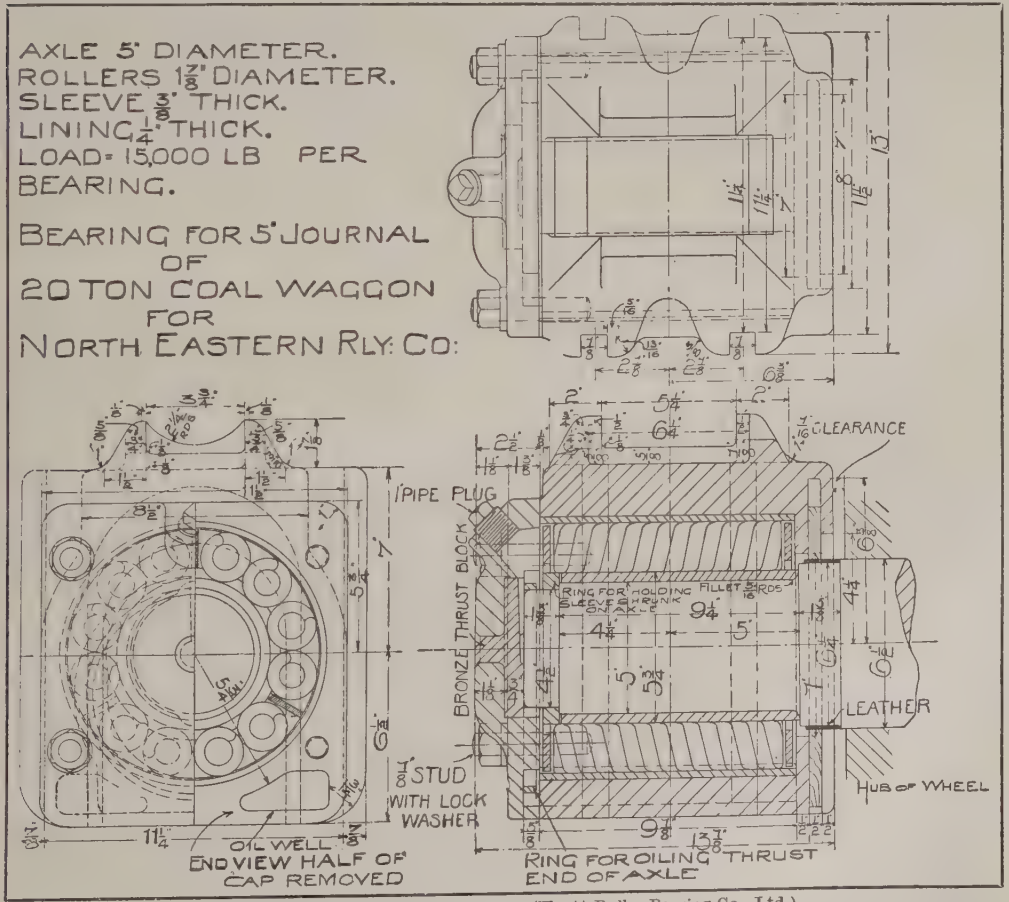
It represents a waggon axle-box as made for the North-Eastern Railway Company. The journal is 5 in. diameter and 9¼ in. long; the end of the axle is reduced in diameter, and a steel ring is shrunk in order to keep the sleeve in place. The outer and inner sleeves are split and ground true as in the previous example; the rollers are kept in a retaining cage. A bronze thrust block is fitted in the end cover of the box, and also an oiling ring to ensure the lubrication of the thrust block. The external arrangement of the box is normal; there is the usual dust-guard at the inner end, and the usual formation of spring seat on the top. The box has grooves for double horn plates, as shown. This bearing after being in use for a twelvemonth was still in perfect condition. This class of bearing is widely used in a lighter form for small cars and mine trucks, and very frequently in such cases the wheels are loose on the axles and contain the roller bearing in their bosses.



68. BALL-BEARING HUB

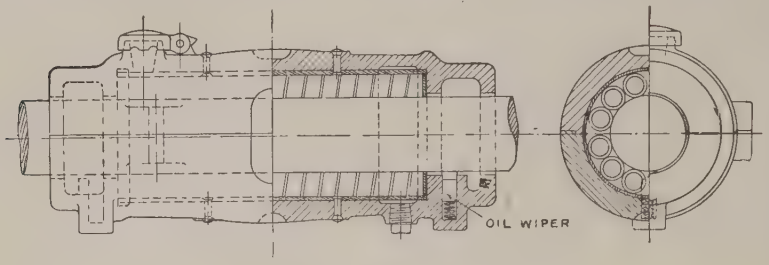
Swivel Bearing. Great saving in power is effected when roller bearings are applied to line shafting. Fig. 70 illustrates the construction of one fitted to such a bearing as is shown in 60 on page 5527. The construction is generally as the preceding examples, but the inner sleeve is omitted. Small metal wipers are fitted at each end to prevent oil from creeping along the shaft, and so getting outside of the bearing. Such a bearing is suitable for high-speed shafting. The scope of the Hyatt flexible roller is much wider than the examples we give. In motor-car work alone it is used very extensively.

Belt Driving. Belts are used for transmitting power from line shafting to machines by means of pulleys; power may also be taken from an engine or a dynamo to shafting by belting and pulleys. Driving belts are usually made of leather, but other materials, such as camelhair, cotton, and indiarubber, are successfully employed, and in some situations are superior to leather, as they are


AXLE 5" DIAMETER.
ROLLERS 1⅞" DIAMETER.
SLEEVE ⅜" THICK.
LINING ¼" THICK.
LOAD = 15,000 LB PER BEARING.
BEARING FOR 5" JOURNAL OF 20 TON COAL WAGGON FOR NORTH EASTERN RLY. CO.
PIPE PLUG
BRONZE THRUST BLOCK
RING FOR HOLDING FILLET RODS
CLEARANCE
LEATHER
HUB OF WHEEL
⅞" STUD WITH LOCK WASHER
OIL WELL
END VIEW HALF OF CAP REMOVED
RING FOR OILING THRUST END OF AXLE

69. WAGGON ROLLER BEARING (Hyatt Roller Bearing Co., Ltd.)

less affected by damp, chemical fumes, etc.; in the case of the camelhair belting, there is less slip between the belt and the pulley, and consequently a better driving effect is obtained. Leather belts are made from the best portion of ox-hides. The amount that can be utilised from an average hide is about 4½ ft. long by 4 ft. wide, and is termed the "butt." The thickness is about $\frac{2}{16}$ in. to ¼ in.; the ultimate strength of the prepared leather is about 3500 lb. per square inch, but this cannot be taken full advantage of in a belt, on account of the jointing which is necessary. If due allowance be made for the laced joint and for a reasonable margin of safety, 350 lb. per square inch may be taken as a safe working load. In calculating the size of a belt for a particular duty it is more convenient to figure the load in lb. per inch of width of belt; 350 lb. per square inch is equal to 66 lb. per inch of width if the belt be in. $\frac{3}{16}$ thick, or 78 lb. if the belt be ¼ in. thick. Double belts are made by cementing two strips of leather together in a superimposed position; they are then sewn or riveted; the resulting thickness is ⅜ or ½ in., as the case may be. Such belts have not quite double the strength of single belts, nor do they drive quite so efficiently, and as they are not so flexible they cannot be used on small pulleys; a 30-in. diameter pulley is quite small enough for a double belt to drive properly.

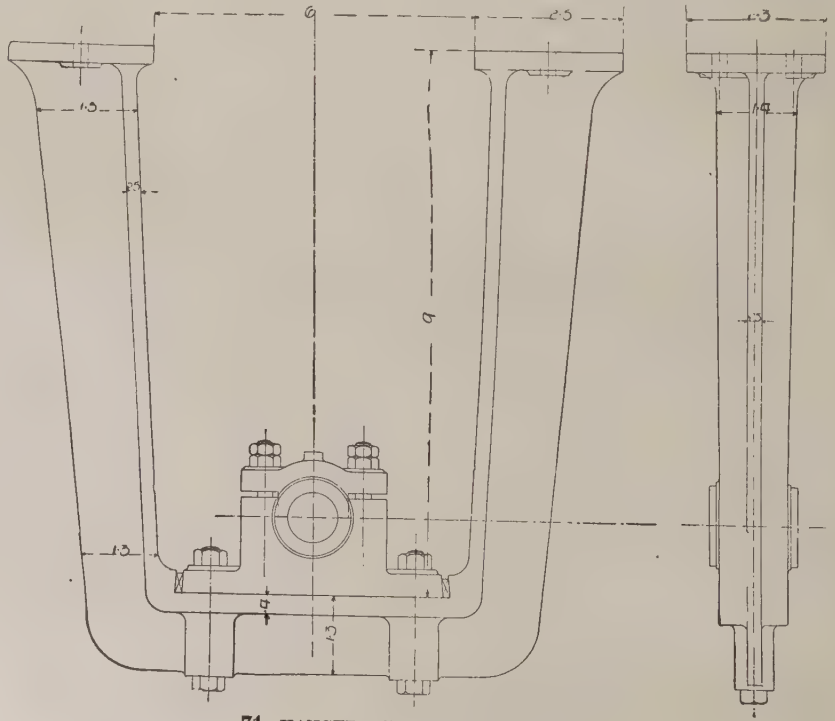


70. SWIVEL ROLLER BEARING

Speed and Power of Belting. The speed of belting varies according to the work it is designed to do; lathes and machine tools have a belt speed of 1000 to 3000 ft. per minute, line shafting may go up to 2500ft. per minute, main drives from engines up to 4000 ft. per minute; some belts run above this latter speed, but no material advantage is gained thereby. The speed of a belt is easily calculated from the diameter and speed of the pulley. The rule is: Multiply the diameter of the pulley by 3·1416, and by the number of revolutions per minute of the shaft. Example: a shaft revolves at 150 revolutions per minute, driven by a pulley 36 in. diameter, the speed of the driving belt is 36 by 3·1416 by 150 = 1414 ft. per minute. A slight inaccuracy, however, is here to be noticed; the speed calculated above is the theoretical speed of the rim of the pulley. Now, a belt "slips" to a certain extent upon the face of the pulley, and by that amount lags behind the speed of the pulley. The usual amount is 1 per cent., so that the actual belt speed in the case above figured out would probably be 1400 ft. per minute.

Power is transmitted from a belt to a pulley or vice versâ by frictional contact, and it therefore depends considerably upon the arc of circumference embraced; if the arc of contact be increased or decreased, so the grip of the belt upon the pulley is increased or decreased, and the driving effect varied accordingly. This is very important to note when designing belt drives. The whole subject of belting is treated exhaustively on page 3848.

JOSEPH W. HORNER



71. HANGER AND PLUMMER BLOCK

Agreement of the Verb with the Subject.
Use of Auxiliaries and the Subjunctive.

FRENCH

Continued from page 5415

By Louis A. Barbé, B.A.

VERBS

Agreement with a Simple Subject

1. Every verb in a finite tense agrees with its subject in number and person: *Le cœur d'une mère est le chef-d'œuvre de la nature,* A mother's heart is Nature's masterpiece.

2. When a verb has for its subject a collective noun, or noun of multitude, followed by another noun in the plural as its complement, that verb is in the singular or in the plural, according as the leading idea is expressed either by the collective or by its complement: *Une nuée de sauterelles obscurcit l'air,* A cloud of locusts obscured the air; *Une nuée de barbares désolèrent le pays,* A cloud of barbarians laid waste the country.

3. After *la plupart,* whether a plural complement is actually expressed or only understood, the verb is always in the plural: *Quand on en vint aux voix, la plupart se déclarèrent de mon avis,* When it came to voting, the greater number declared themselves of my opinion.

4. After the adverbs of quantity, *peu, beaucoup, moins, assez, trop,* followed by a plural, the verb is always in the plural: *Beaucoup de gens promettent; peu savent tenir,* Many people promise; few know how to keep (their promises).

5. When *peu* is preceded by *le,* the verb is in the singular if *le peu* expresses want or deficiency: *Le peut de gens avec qui on peut communiquer des sciences abstraites m'en avait dégoûté,* The few (= the lack of) people with whom one can discuss the abstract sciences had put me out of conceit with them.

When *le peu* expresses a small quantity, or a small number, the verb agrees with the noun following it: *Le peu d'amis que j'avais sont venus à mon secours,* The few friends I had have come to my help.

6. *Plus d'un,* though expressing plurality, requires the verb that follows it to be in the singular: *Plus d'un doit son succès à sa persévérance autant qu' à son talent,* More than one owes his success to his perseverance as much as to his talent.

7. The verb of which *tout le monde* is the subject is always in the singular: *Tout le monde est sujet à l'erreur,* Everybody is liable to error.

8. When preceded by *ce,* the verb *être* is in the third person singular if it is followed by a plural pronoun of the first or of the second person, or by two or more nouns in the singular: *C'est nous qui avons le plus souffert de sa tyrannie,* It is we who have suffered most from his tyranny.

9. Though preceded by *ce,* the verb *être* requires to be in the plural; if it is followed by a plural noun or by a personal pronoun in the third person plural: *Ce furent les Phéniciens qui inventèrent l'écriture,* It was the Phœnicians who invented writing.

10. When the verb *être* preceded by *ce* is followed by two (or more) substantives of which one is singular and the other plural, it takes the number of the substantive nearest to it: *Ce sera le même théâtre et les mêmes décorations.* It will be the same theatre and the same decorations.

11. When the verb *être* preceded by *ce* is equivalent to the impersonal verb *y avoir,* it may, if followed by a plural noun, be either in the singular or the plural itself: *C'était* (or *c'étaient*) *tous les jours de nouvelles plaintes,* There were new complaints every day.

12. The verb *être* preceded by *ce* remains in the singular if it is followed by a noun and a numeral adjective which, though plural in form, convey an idea of unity, and may be replaced by the singular: *C'est quatre heures qui sonnent,* It is four o'clock that is striking—that is to say, *la quatrième heure,* the fourth hour.

Agreement with Several Subjects

1. When the subject of a verb consists of several nouns or pronouns in the singular, the verb itself is in the plural: *L'hirondelle et le rossignol annoncent le retour du printemps,* The swallow and the nightingale announce the return of spring.

2 When the various parts of the subject are not of the same person, the verb is in the plural and agrees with the person that has priority. In that case, it is usual, but not essential, to introduce an additional plural pronoun representing that person: *Vous et moi (nous) sommes contents de notre sort,* You and I are content with our lot.

3. The verb may be in the singular when the various nouns of which the subject consists are practically synonymous.

4. When two subjects are joined either by *ni* or by *ou,* the verb is usually in the plural, unless it is obvious that one subject excludes the other: *Ni l'or ni la grandeur ne nous rendent heureux,* Neither gold nor greatness make us happy. *Ni Corneille ni Racine n'est l'auteur de ces vers,* Neither Corneille nor Racine is the author of those verses.

5. A verb having *l'un et l'autre* for its subject must be in the plural: *L'un et l'autre rapportent les mêmes circonstances,* The one and the other (= both) record the same circumstances.

Complement of the Verb

1. The same noun may be the complement (or object) of two verbs, provided both verbs govern the same case: *Les enfants doivent aimer et respecter leurs parents,* Children should love and respect their parents. Here, *parents* is the direct object (or accusative) of both *aimer* and *respecter.* It is incorrect to say: *Les enfants doivent obéir et respecter leurs parents,* because *obéir* requires an indirect object (or dative), whilst *respecter* governs a direct object (or accusative). The proper construction is: *Les enfants doivent obéir à leurs parents et les respecter,* Children must obey their parents and respect them.

2. When a verb has several complements joined by *et, ou,* or *ni,* all these complements must be of the same kind—*i.e.,* either all nouns, or all infinitives, etc.; but not one noun and one infinitive: *Il aime le chant et le dessin,* He likes singing and drawing; *Il aime à chanter et à dessiner,* He likes to sing and to draw.

Both these sentences are correct; but it would be incorrect to say: *Il aime le chant et à dessiner,* He likes singing and to draw.

3. If a verb has both a direct and an indirect complement, the direct complement (or accusative) comes first, provided both are of equal length: *On doit préférer la mort à l'esclavage*, We should prefer death to slavery.

4. If the two complements are of unequal length, the shorter usually comes first: *L'avare sacrifie à l'intérêt son honneur et sa vie.* The miser sacrifices honour and life to interest.

Use of Auxiliaries

1. All transitive verbs take *avoir* for their auxiliary: *J'ai donné; tu avais fini; il aura reçu; vous auriez vendu.*

2. Most intransitive verbs take *avoir* for their auxiliary: *Il a succombé; elle avait régné.*

3. All reflexive verbs are conjugated with *être* in their compound tenses: *Je me suis blessé; vous vous seriez aperçus.*

4. The passive voice consists throughout of the verb *être* with a past participle added to it: *Il est aimé; ils ont été battus.*

5. The following intransitive verbs are always conjugated with *être*:

Aller, to go; *arriver*, to arrive; *choir*, to fall; *décéder*, to die; *échoir*, to fall due; *éclore*, to be hatched, to blossom; *entrer*, to enter; *mourir*, to die; *naître*, to be born; *repartir*, to set out again; *ressortir*, to go out again; *retourner*, to go back; *venir*, to come; and the derivatives *rentrer*, to come back, to re-enter; *devenir*, to become; *intervenir*, to intervene; *parvenir*, to succeed, to attain to; *provenir*, to proceed from; *redevenir*, to become again.

6. A certain number of intransitive verbs, though almost always conjugated with *être*, are occasionally to be found conjugated with *avoir*. They are:

Descendre, to go down; *monter*, to go up; *partir*, to set out, to go off; *retomber*, to fall again; *tomber*, to fall.

7. Any intransitive verb used transitively requires *avoir* for its auxiliary: *Avez-vous descendu nos bagages?* Have you taken down our baggage?

8. A certain number of verbs, of which the following are the chief, are conjugated with *avoir* or with *être*, according as they denote action or state resulting from action:

Accourir, to run up; *cesser*, to cease; *changer*, to change; *croître*, to grow; *déborder*, to overflow; *dégénérer*, to degenerate; *disparaître*, to disappear; *échouer*, to run aground, to fail; *embellir*, to become handsomer; *grandir*, to grow up; *grossir*, to increase in size; *maigrir*, to become thinner; *passer*, to pass; *rajeunir*, to become young again; *vieillir*, to grow old. *Cet enfant a bien grandi en peu de temps*, That child has grown a great deal in a short time. *Comme il est grandi!* How grown (= tall) he is!

9. Some verbs have different meanings, according as they are conjugated with *avoir* or with *être*. Such are, *Convenir*, to suit, to agree: *Cette maison nous a convenu*, That house has suited (pleased) us. *Nous sommes convenus d'acheter cette maison*, We have agreed to buy that house.

Demeurer, to dwell, to stop: *Il a demeuré longtemps à Paris*, He lived a long time in Paris. *L'affaire en est demeurée là*, The matter stopped there.

Échapper, to escape notice, to be forgotten, to slip from, to be said unwittingly: *Ce que je voulais vous dire m'a échappé*, What I wished to tell you has escaped me (*i.e.*, my memory). *Il lui est échappé un mot qu'il ne voulait pas dire*, A word he did not wish to say has escaped him.

Use of the Subjunctive

1. The verb of the subordinate clause must be in the subjunctive when the verb of the principal clause expresses surprise, admiration, wish, consent, prohibition, doubt, fear, command: *Je m'étonne qu'il ne voie pas le danger où il est*, I am astonished that he does not see the danger in which he is.

2. The verb of the subordinate clause must be in the subjunctive when the verb of the principal clause is either negative or interrogative: *Je n'ai employé aucune fiction qui ne soit une image sensible de la vérité*, I have used no fiction but is a sensible image of truth. *Croyez-vous qu'il vienne?* Do you think he will come?

Exception: When the interrogation is merely formal, and really amounts to a direct statement, the subjunctive is not required: *Croyez-vous que les Parisiens sont des sots?* Do you think Parisians are blockheads?

3. The verb of the subordinate clause must be in the subjunctive after impersonal verbs and phrases: *Il vaut mieux qu'il ne vienne point*, It is better he should not come. *Il importe que vous y soyez*, It is important that you should be there.

Exception: (*a*) The indicative is required after *il s'ensuit*, it follows; *il résulte*, it results; *il arrive*, it happens; and after impersonal phrases in which there occurs an adjective expressive of certainty, such as *évident, sûr, certain, vrai*, except when these are either negative or interrogative: *Il arrive souvent qu'on est trompé*, It often happens that we are mistaken.

(*b*) The verb *sembler*, though used impersonally, requires the indicative if it is preceded by one of the personal pronouns *me, te, nous, vous, lui, leur*; but, if used negatively or interrogatively, it follows the rule: *Il me semble qu'il n'y a pas de plus grande jouissance que celle de faire des heureux*, It seems to me that there is no greater happiness than that of making people happy. *Il ne me semble pas que l'on puisse penser différemment*, It does not seem to me that anyone can think otherwise.

4. The verb of a relative clause must be in the subjunctive if it does not express an actual fact, and if the relative clause implies some purpose regarding the antecedent, or some unattained result. To express what is regarded as a fact or a certain result the indicative is used: *Si je vais à Londres, ce sera avec quelqu'un qui sache parler anglais*; *Si je vais à Londres, ce sera avec quelqu'un qui sait parler anglais.* Both these sentences mean: If I go to London it will be with someone who can speak English. In the first of them, the use of the subjunctive indicates that such a person has not yet been secured; in the second, the use of the indicative implies that such a person is actually available.

To be concluded

Commercial Gases and the Methods of Producing Them. Meters and Meter Mechanism. Gasfitting.

GAS MANUFACTURE—2

Wood-gas. The process of manufacturing wood-gas is practised only in those countries where wood is plentiful and coal expensive. Riche's gas plant is used, the retorts being of cast iron. The gas consists of hydrogen, carbon monoxide with marsh-gas and ethylene, the carbon monoxide being in larger proportion than in coal-gas, some of it being due to the decomposition of the water which is contained in all wood. Several methods have been proposed for the preparation of peat-gas, which promise great possibilities on account of other products which result. These gases can be carburetted to increase their illuminating powers.

Air-gas. What is known as *air-gas* consists of air carburetted with the vapours of highly volatile hydrocarbons, such as gasoline, carburine, and benzene. The hydrocarbon needs to be very volatile, and of constant and uniform composition. One plant which has been satisfactorily working for some time consists essentially of three parts: (1) A large, shallow cylindrical copper tank, holding 250 gallons, buried some 30 ft. or more from the building, and filled with gasoline through a pipe and closed airtight by a screw tap. Two other pipes, an inlet and outlet, are fitted into the top of the tank, and pass underground to the cellar of the building. (2) In the cellar a pump, worked by a weight on pulleys, forces air through the inlet pipe on to the surface of the gasoline in the tank. Evaporation is rapid—gasoline boiling at from 35° C. to 70° C.—and the mixture of vapour and air is driven through the outlet pipe into (3) an automatic mixer, by which a definite and known quantity of air can be added, so that the proper proportion for burning may be constantly maintained. The apparatus is simple, and requires little attention.

A similar air-gas can be made with ether, but in this case the air is passed through a box containing a fibrous substance which has been saturated with ether.

Hydrogen. Within the last few years the necessity has arisen for the production of large quantities of pure hydrogen cheaply, for use in airships and in the new industry of fat hardening. The chemical method formerly employed, in which dilute sulphuric acid acts upon iron, cannot be used, owing to the enormous quantities of materials which are required. For example, an airship of no exceptional capacity requires from 250,000 cubic ft. to 500,000 cubic ft. of hydrogen to inflate it; and, taking the lower capacity, this means the use of 18 tons of iron and 31 tons of sulphuric acid. The working processes are those of Linde-Frank-Caro and Messerschmitt. The first-named starts with water-gas, separates the carbon monoxide and nitrogen by cold and pressure—these two gases being more readily liquefied than hydrogen—and the carbon dioxide by absorption in caustic soda solution. The Messerschmitt process combines the production of hydrogen by the action of steam on iron, and the reduction of the resulting iron oxide by water-gas, the two reactions taking place at 700° C. and 800° C. respectively.

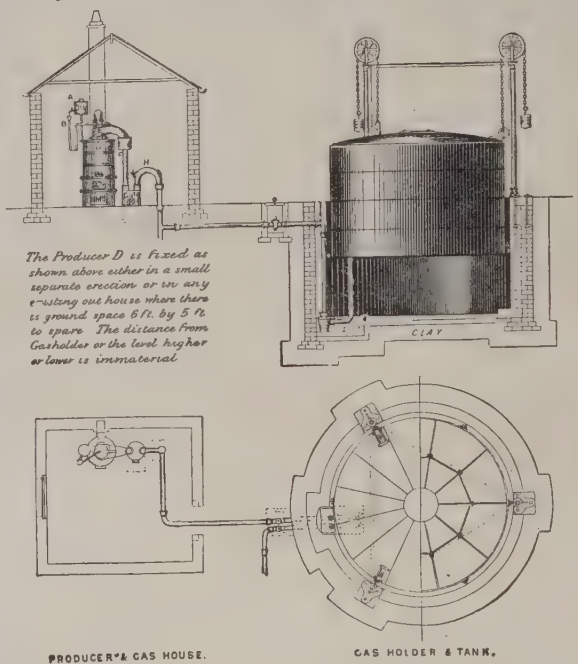
Oil-gas. When oil is subjected to destructive distillation it is broken up—"cracked" is the technical term—and a gas possessing high luminosity and heating power is obtained. The earliest process was invented by John Taylor in 1815, and shortly afterwards a method of compressing the gas was devised so that it could be readily transported—hence the name *portable gas*. It is a convenient method of illuminating railway carriages, buoys, and lightships. The process of "cracking" oil is the basis of new methods of making petrol from paraffin.

Pintsch's Apparatus. The Pintsch system is one in use in many railway companies, the following being a description of the process as used by the Great Northern Railway at Holloway. The plant was designed to make 60,000 cubic ft. of gas per day. The 10 in. D-retorts in which the oil is cracked are made of 1 in. metal, and are 6 ft. in length; they are worked in pairs, and are kept as nearly as possible at a cherry-red heat. Each pair will make from 300 cubic ft. to 400 cubic ft. of gas per hour, and 600,000 cubic ft. to 700,000 cubic ft. of gas before they require renewal. Immediately before the gas enters the hydraulic main, a $\frac{3}{4}$-in. iron pipe, provided with a stop-cock, is tapped in, so that the colour of the gas may be seen, this being the practical test applied to ascertain the quality of the gas, and whether the proper quantity of oil is being admitted. Another test for regulating the supply of oil is to drop a small quantity of the tar from the gas-main upon a sheet of white paper; if too much oil is being admitted to the retort, a greasy ring will be found round the spot of tar; but if the right quantity is being used, no ring will appear.

The furnaces consume 160 lb. to 180 lb. of coke for every 1000 cubic ft. of gas produced. The oil used is a once-refined shale oil; it runs to the retorts from a galvanised iron cistern of 50 gallons capacity through a 1-in. iron pipe, at the end of which is fixed a gun-metal micrometer cock for regulating the supply. From this supply pipe the oil flows into a small funnel attached to a $\frac{3}{4}$-in. siphon pipe, 12 in. deep, connected with the retort; it then falls on a loose tray, preferably of steel, and is instantly converted into a dense brown vapour. The gas issuing from the retorts passes to the hydraulic main, then through air condensers, washers, and purifiers into the meters and gasholders. The purifiers contain a mixture of two parts of slaked lime to one part of sawdust, placed on wicker trays, and are recharged every week. The cylindrical steel storeholders are 17 ft. 6 in. in length, and 4 ft. 3 in. in diameter. They are tested by hydraulic power to 300 lb. per square inch, and are provided with a pressure gauge registering up to 200 lb. per square inch. The gas is forced into the storeholders through a 1-in. extra-strong lead pipe by compressing engines. Each holder is provided with a cock at the bottom for drawing off the condensed hydrocarbon, of which about a gallon is obtained from every 1000 cubic ft. of compressed gas. Each gallon of oil yields 80 cubic ft. to 85 cubic ft. of gas. The oil is run in at about 12 gallons per hour. Other systems are the Keith, Pope, and

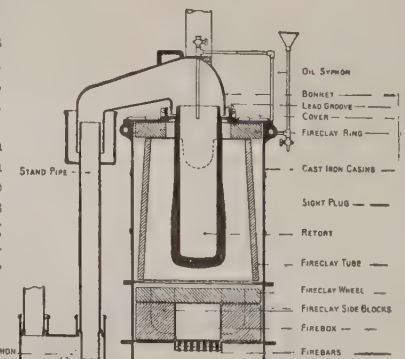
Peebles processes. The object aimed at in the last-named—Young, of Peebles—is to produce an oil-gas specially adapted for carburetting water-gas and enriching coal-gas.

Mansfield's Apparatus. A form of oil-gas plant much used for private installations is that made by Mansfield & Sons, Ltd., Liverpool. The illustration [7] shows a sectional elevation of the complete plant, the details of the gas producer being shown in the smaller figure [8]. The producer has a retort suspended in a cast-iron casing, lined with fireclay fittings. The top of the retort is made gas-tight by a lead joint. When the retort is hot enough to make gas, the lead melts, the bonnet sinks into it, thus making an automatic joint. The retort is heated by a coal or wood fire, and a strong red heat as seen through a sight plug is maintained throughout the gas-making process. Oil is stored in a suitable tank in any part of the building. From this tank a pipe is led to the oil syphon of the producer. A small cock attached to the end of the pipe regulates the flow of oil which is permitted to run in a fine stream into the funnel of the oil syphon. Through this it passes into the retort, and is converted into gas. The gas rises into the bonnet, and passes down the standpipe into the hydraulic main, through which it passes into the gasholder. The materials from which oil-gas can be made include creosote, palm-oil, castor-oil, coconut-oil, Rangoon-oil, kerosene, fish-oil, tallow, and unrefined fat.


The Producer D is fixed as shown above either in a small separate erection or in any existing out house where there is ground space 6 ft. by 5 ft. to spare. The distance from Gasholder or the level higher or lower is immaterial
CLAY
PRODUCER & GAS HOUSE.
GAS HOLDER & TANK.

7. MANSFIELD'S OIL-GAS PLANT
(Mansfield & Sons, Ltd, Liverpool)

Water-gas. When water, in the form of steam, is passed through a mass of incandescent coke, the water molecule is decomposed, its constituent elements combining with the coke—a form of carbon—to make carbon monoxide or carbon dioxide and hydrogen. If the temperature of the coke is at about 500° C., carbon dioxide and hydrogen are formed, but at 1,000° C. the products are carbon monoxide and hydrogen. The mixture of gases thus obtained is known as *water-gas*. In discussing the various combustible and non-combustible constituents of gas, it was pointed out that carbon monoxide is combustible, but that carbon dioxide is non-combustible, and thus of no value as an illuminating or heating gas. The object will be, therefore, to produce carbon monoxide in preference to carbon dioxide if the usual properties of a gas are desired. There are, however, cases in which the carbon dioxide is preferable, as will presently be explained. The reaction in making water-gas takes place in two stages—the first, in which the water molecule is decomposed, absorbs heat in course of the change; and the second, when the carbon monoxide is being formed, is a reaction where heat is given out. The process is, on this account, an intermittent one. Air is blown in a blast over glowing coke till the mass becomes intensely hot, the gas being given off at this stage being known as *producer* or *generator gas*. When the coke is hot, steam is blown in in place of the air, water-gas being produced. The reaction rapidly cools the coke, so that it becomes necessary to stop the injection of steam and again blow the coke to incandescence by turning on the air blast. The producer or generator gas is passed into a second vessel filled with firebricks, which it raises to a white heat, and it is into this second vessel or *superheater* that the steam is passed before it goes into the fuel in the generator. Thus water-gas is made for about four minutes, and the heating-up occupies about ten minutes. This question of producer gas will be dealt with later.



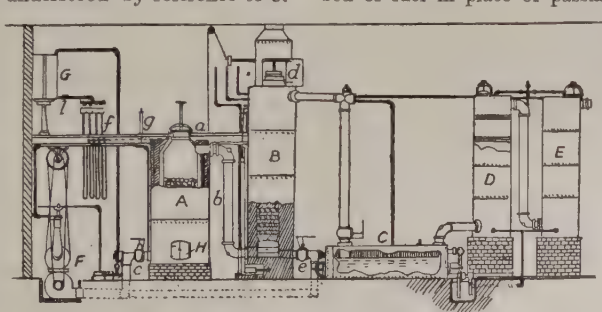
8. DETAILS OF THE GAS PRODUCER

Carburetted Water-gas. It will be remembered that both hydrogen and carbon monoxide give *blue* or non-luminous flames, and to make the gas give a luminous flame it is *carburetted* in a way similar to the enriching process referred to in the article on coal-gas. This carburetting is effected by the hot process in an additional chamber, in which oil is decomposed and the vapours mixed with the water-gas in a manner which will be best understood by reference to our remarks on oil-gas. The enriching may also be carried out in the cold process by allowing the gas to pass into a vessel containing carburine, a mixture of gasoline and benzene, which vessel is surrounded by hot water

to promote evaporation. This, again, will be readily grasped when the section of this article on air-gas is read. Carburetted water-gas is much used in the United States, where gas-coal is comparatively dear, and hence cannot advantageously be used for preparing coal-gas. In this country the large gas companies are in the habit of mixing about 10 per cent. of carburetted water-gas with the coal-gas as a convenient method of raising the candle-power of the latter to the standard candle-power. Water-gas is more poisonous than coal-gas, as it consists mainly of carbon monoxide and hydrogen, the former a very poisonous gas. Moreover, as water-gas is inodorous, it is not so easy to detect leakage. This objection can be got over by giving the gas a strong smell by passing over naphthalene or impregnating with isocyanides or organic sulphides. The objection does not arise in cases where the carburetted water-gas is mixed with coal-gas, but the poisonous properties of carbon monoxide form a reason why the proportion of water-gas should not be unduly increased. If it were not that the public want a gas to give a luminous flame always it could very well be made luminous at the burner by means of an incandescent mantle.

Advantages of Carburetted Water-gas. After referring to the disadvantages of water-gas, it is only just to state the advantages. These are that the gas can be made of high illuminating power; economy in wages, since fewer workers are required than for the manufacture of coal-gas; the small cost of the installation; small area occupied by the plant; the utilisation of coke; freedom of the gas from ammonia and small amount of sulphur compounds to be removed. There is no need to remove the small amount of carbon dioxide, and the apparatus can be got ready for working in less than four hours, which is a convenience in case of a suddenly increased demand for gas. In coal-gas works it is economical to use the red-hot coke as it is drawn from the retorts.

Lowe's Water-gas Process. Having stated the chief points in the manufacture of water-gas, a few details of some of the processes actually employed may be given. In the Tessié du Motay process the water-gas is made from anthracite (in place of coke) and steam, then purified by passing through a lime-box, and finally carburetted by the cold process, the resulting mixture of water-gas and naphtha, or carburine vapour, being led through specially arranged retorts to ensure decomposition of the hydrocarbon, and finally stored. Lowe's process will be best understood by reference to **9**. In this the decomposition of the naphtha is carried out simultaneously with the production of the water-gas—that is, it is carburetted by the hot process. A is the generator, filled with anthracite through the manhole *a*. A fan, F, sends a current of air into the generator through the valve *c*; the gases escaping through the pipe *b* into the superheater B, filled with stacked firebricks; when the gases contain enough carbon monoxide to burn, air is also blown in at the base of the superheater



9. LOWE'S WATER-GAS PLANT

through the valve *e*, the products of combustion escaping into the open at the top through *d*. When the requisite temperature is attained, *c*, *d*, and *e* are closed, and the fan nearly stopped, a very gentle current being still maintained through small orifices in *c* and *e*, purposely arranged to prevent back-rush of water-gas into the air main, which otherwise might cause an explosion. Steam is then turned on at the base of the generator, and a stream of naphtha at the top supplied from the tank by means of a series of distributing tubes. The mixture of hydrogen, carbon monoxide, and a little carbon dioxide formed in the generator, vaporises the naphtha, and the mixed gases act on one another in the superheater, ultimately producing an illuminating gas of high quality, when the steam and naphtha supplies are properly proportioned. The gas is washed in the purifier C, and the two towers, D and E, and stored. The steaming operation is continued for twenty minutes, when the steam is shut off, more anthracite filled in through the manhole, and the cycle of operations begun again. Every few hours (six to twelve) the doors, H, at the base of the generator are opened and the anthracite residue raked out. As will be seen, the product is a mixture of oil and water-gases. All sorts of variations of this process are in use. In one the superheater is filled with lumps of lime to free the gas from carbon dioxide. The Granger plant is arranged so that the naphtha is forced in under pressure, thus facilitating its gasification, and in the Hanlon and Leadley process bituminous coal is used in place of anthracite. Humphrey's apparatus consists of two generators, two carburettors, and two superheaters. The generators are connected by means of a flue, and each of them is also in connection with a carburettor and a superheater, the object being to enable the process to be alternately worked from the left and right.

The Dellwik-Fleischer System. In the water-gas processes just described, the fuel is raised to incandescence by blowing air through so deep a bed of fuel that the chief products are carbon monoxide and nitrogen (from the air). One pound of carbon develops only 2,400 heat-units when burnt to carbon monoxide, but 8,080 when burnt to carbon dioxide, for the reason explained in the opening remarks about the water-gas reaction. Carl Dellwik has devised a process by which the products of the "blow" are carbon dioxide and nitrogen, and thus the additional heat-units are made available in raising the temperature of the bed of fuel in place of passing into the producer gas. The result is that twice as much water-gas is obtained, the extra heat reduces the "blow" period, and allows the "run" (steam admission period) to be prolonged. The flow of steam to the fuel is regulated so that even at the end of the run there is no excess of steam to oxidise the carbon monoxide to dioxide. A ton of good coke yields 70,000 cubic ft. of water-gas in place of 34,400 by the older process. Under the older processes the cost of 1,000 cubic ft. of water-gas is from 4d.

to 6d.; by a large Dellwik-Fleischer installation the cost is below 3d. The gas produced by the Dellwik process has been successfully utilised at Cleethorpes for mixing with coal-gas by passing it into the retorts during carbonisation. Dr. Fleischer improved the original Dellwik process, hence his name becomes to be associated.

Methane Hydrogen Gas. This is the name of a process which has been successfully adopted at Sligo and Truro. The generator is filled with coke, and then blown up to incandescence, the waste gas escaping part of the way up the generator to the stack pipe, so that the fuel above is dried and heated before it comes down into the hot zone, and also serves to filter out the finely divided carbon produced during the "run." When the requisite temperature has been attained the valves are altered, and steam and tar are injected into the body of incandescent fuel. The tar is decomposed into carbon and gaseous products—containing methane—the steam combining with the coke and separated carbon to produce water-gas. A further quantity of steam injected at the bottom of the generator serves to produce ordinary water-gas, which passes away and mixes with the other gases. This gas is mixed with ordinary coal-gas in the foul main, where it takes up a considerable quantity of illuminants from the hot tar. Methane hydrogen is claimed to take up benzene better than ordinary water-gas in the carburetting process. Such a carburetted methane-hydrogen gas costs 8·92d. per 1,000 cubic ft. at Truro.

Producer-gas. This term is applied to the gas obtained in the producer or generator of the water-gas apparatus. It will be remembered that air was passed into the generator filled with coke, a gas was produced which was used to heat the second chamber, into which steam was driven and decomposed into water-gas. This may be taken as an instance of the utilisation of producer-gas; but it finds many employments in metallurgical operations, boiler firing, gas-engines, and in glass and pottery manufacture. It is also known as *Siemens' gas*, because producer-gas was economically made in a regenerative furnace of the Siemens' type. The producer-gas is made in numerous different furnaces. In some the gas is enriched by being used for distilling coal; and, again, if steam and air are injected, a mixture of producer-gas and water-gas is obtained—the so-called *semi-water-gas* or *Dowson gas*. The amount of steam that can be used is limited—from the reasons which we have dealt with in the paragraph on water-gas—and is arranged so that the heat generated by the air equals the heat absorbed by the steam. Producer-gas contains a large proportion of nitrogen from the air that is injected, and as nitrogen is a non-combustible gas, producer-gas is comparatively poor in heating properties; its flame also is non-luminous. The French call the gas *gaz pauvre*, or *poor gas*. Although the gas is poor, it can be produced in large quantities, and very cheaply. On this account producer-gas can be used freely, and still be an economical source of power. Carbon dioxide is also found in producer-gas, but the object is to make carbon monoxide in preference, as only the latter is combustible. Some average analyses will be given later in comparing the composition of several gases. In many producers anthracite is used in place of coal, as the tar produced with bituminous coal entails purification plant, the gas having a clogging action when used in gas-engines if it contains tar.

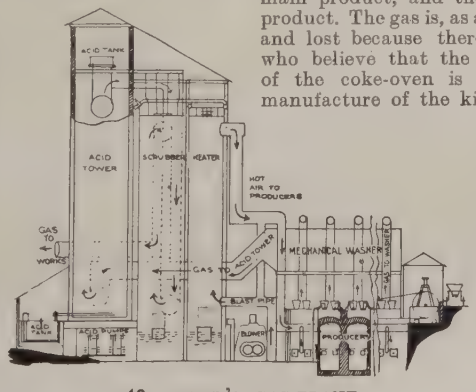
Types of Producers. The Bischof producer of 1839 is the basis of most types that have since been invented. The Siemens' gas producer was brought out in 1861. These early types of producers had open ashpits, with draught produced as in ordinary furnaces, and much heat was lost. Succeeding types are provided with closed hearths, and are produced with numberless variations in the arrangement of the parts. Prof. A. H. Sexton divides closed producers into the following five groups: (1) bar bottom; (2) solid bottom; (3) water bottom; (4) automatic; (5) blast furnace. The Dowson producer, one of the best known of the bar bottom type, was patented in 1878 (No. 3997) and 1881 (No. 2859). The air and steam were admitted through the bars. The clinker from the fuel accumulates on the bars of the furnace, and needs stoking to remove it. The Wilson producer of 1876 (No. 3949) is an example of the solid-bottom producer. The fuel rests on the solid bottom of the generator upon a layer of clinker. The clinker is drawn off near the bottom, and air blown in just above the layer of clinker, which is always left in the producer. The clinkers are removed every twenty-four hours through narrow side doors, bars being put across to support the fuel during the operation. Solid-bottom producers are thus intermittent, but this is got over by arranging a water-seal as in the water-bottom producers. The ashes fall into water, and no gas escapes. The heat of the ashes vaporises some of the water, which passes into the producer. The Duff producer (patent 15646, of 1901), the Smith and Wincott producer (patent 12895, of 1901), and the Wilson water-bottom producer are representative examples of this type. In the automatic producers the ashes are continuously removed by mechanical means. The Wilson automatic producer does this by a constantly revolving screw, which slowly pushes out the ashes. Space will not permit of details being given of the numerous producers that have been patented, and which fall under one or other of the above types. The chief improvements consist in means of removing the tar from the gas; heating the air and steam before use; special methods of charging; special arrangements for supplying the air and steam; varieties in grates; producers raising own steam; arrangements for breaking up clinker or fuel; supplying the air and steam at the top and drawing off the gas lower down; feeding at the bottom.

Suction Gas-producers. The constantly increasing use of gas-engines has ensured the evolution of the gas producers along economic lines. The types hitherto dealt with have needed air and steam forcing into the producer, with the consequence that the gas was under slight pressure, from which fact the type has been distinguished as *pressure gas-producers*. From these a new type requiring neither steam-jet nor air-blower has been evolved, the air being drawn into the producer by a suction pump attached to the gas-engine, being known as *suction gas-producers*. With the older type of pressure producers a boiler was needed to generate steam, and a gasholder in which to store the gas for use; while with the suction type the gas is taken direct to the combustion chamber of the engine. The boiler is supplanted by an *evaporator* or *vaporiser*, which in small plants is built frequently on the top of the producer in the form of a water jacket, and in large plants close to the producer in the form of a tubular evaporator. This evaporator is generating the steam required by utilising the waste heat of the producer and of the gas, which is of considerable advantage, as

compared with the old system, the firing of a separate boiler being dispensed with. The advantage of a suction gas-producer are automatic generation of the gas by the engine; highest and best utilisation of fuel; no boiler or gasholder required; can be erected without danger in any convenient place; easy to start and to run; no soot, smoke or odour; no explosion possible; and small floor space required. The origin of the type is the Benier producer, which was patented 1894, and has been specially developed on the Continent. A complete suction gas-producer plant consists of a blower which, up to 150-h.p., is driven by hand; a producer, an evaporator, an overflow water-pot, a scrubber, and a small equalising tank or *expansion box*. In plants above 75-h.p. a sawdust scrubber is advantageously inserted behind the wet scrubber, and in plants where two or more engines are fed from the same producer a small gasholder with automatic regulation is used.

The producer consists of an iron shell lined with firebrick and provided with a suitable hopper. The grate area, according to the quality of fuel, is 0·8 to 1 sq. ft. for every 10 horse-power. The scrubber consists also of a sheet-iron shell, and is filled preferably with broken coke. Before starting the engine the fuel in the producer is heated up by means of a blower until the gas is burning well at the test-cock. When this point is reached the blower is stopped, and the engine started in the usual way. The engine then draws by its own sucking action the necessary amount of air and steam through the fuel, and is producing its own power-gas. From the producer the gas is drawn through the scrubber and the equalising tank to the engine. The gas-making process continues so long as the engine is moving, and stops when the engine stops. Anthracite, charcoal, or coke can be used in suction gas-producers.

Mond Gas. Dr. Ludwig Mond, in studying the question of obtaining a cheap fuel gas, has evolved a method in which slack coal is used, and the ammonia produced by the combustion is recovered. The gas is really a producer-gas, but is, on account of the novel method of production, generally distinguished as Mond gas. The gas is being produced on an enormous scale, and is distributed by means of pipes in a large district in Lancashire. The following is a brief description of the plant used, which will be made clearer by referring to the illustration [10]. The producer is provided with a water-seal, and is constructed so as to allow the ash, which is the only residue, to descend into the water, from which it is easily removed without interfering in any way with the working of the producer. The process of combustion is carried out at a comparatively low temperature, with the twofold object of preventing the formation of clinkers in the producer and of providing against the destruction of ammonia. This is accomplished by introducing into the producer a blast of hot air and steam. The quantity of steam required when it is desired to recover the ammonia from the gas is equal to 2½ tons per ton of fuel gasified, but of this about 1 ton is automatically recovered and used over and over again. After leaving the producer the gas is passed through a regenerator arranged so that part of the heat or gas and steam entering it is transferred to the blast of air and steam on its way from the air-heating tower to the producer, the gas being consequently cooled to a corresponding temperature. The gas then passes to a mechanical washer, which further reduces the temperature and removes all soot and dust. The next step is the recovery of the ammonia, and the gas is for this purpose passed through an acid tower, where the ammonia is completely absorbed by a dilute solution of sulphuric acid. The solution circulates through the acid tower again and again until it contains from 36 per cent. to 38 per cent. of sulphate of ammonia. Continuity of the process is provided by adding from time to time fresh supplies of sulphuric acid and withdrawing corresponding quantities of sulphate liquor. The latter is evaporated, yielding at once a solid sulphate of ammonia of good saleable quality. After the gas has been washed of its ammonia products, it passes through a final cooling and cleaning water-tower, and is then ready for use. As the gas is cooled in this final tower the steam with which it was saturated is condensed, and the cleaning water which enters the tower cold is delivered hot; and this, after passing through tar-separators, is again pumped to the air-heating tower to heat the air required for the producer blast. The final cost of 140,000 cubic ft. to 160,000 cubic ft. of gas from a ton of fuel is put at 4s. 11d. About 90 lb. of sulphate of ammonia is obtained from each ton of coal.



10. MOND'S GAS-PLANT

Coke-oven Gas. In the manufacture of coal gas, as we have seen, the gas is the main product, and the coke, although used for several other purposes, is the by-product. The iron smelter requires a coke that is compact, heavy and even, and to produce such a coke special furnaces are used, known as *coke-ovens*. Here the coke is the main product, and the gas given off is the by-product. The gas is, as a rule, completely neglected and lost because there are many iron makers who believe that the recovery of the products of the coke-oven is not consistent with the manufacture of the kind of coke which is most suitable for the blast furnace. As some 13,000,000 tons of coal is coked in the United Kingdom in beehive ovens for the manufacture of pig iron, it will be apparent that the loss is tremendous. Many recovery or by-product coke-ovens have been invented, the principle being that the gas is drawn away from the ovens and means employed to remove the tar and ammonia. The gas is used for heating the coke-ovens, in gas-engines, and is now being adapted for illuminating purposes. In large installations of by-product coke ovens two kinds of gas are separately collected; the richer gas coming off during the first part of the process can be used as an illuminant, the second portion of the coking yielding fuel gas. The other by-products, tar and ammonia, are recovered by similar methods to those used in purifying coal gas, and already described.

Blast-furnace Gas. The blast furnace used for smelting iron ore generates a large quantity of inflammable gas known as *waste gas.* The last name expresses the universal practice of iron makers up to a few years back, when efforts were directed to utilising this wasted form of fuel. The gas, owing to the velocity with which it passes from the furnace, is laden with dust; but this is neglected when the gas is employed for heating the blast, or as fuel under boilers. When required for use in gas-engines, the gas must be cleaned, or it soon blocks up the valves of the explosion chamber. Properly cleaned furnace gas is an ideal gas for gas-engines, as, when mixed with air and compressed, it is found to be a slow but very reliable explosive. A portion of the gas is used for driving the gas-engine which produces the blast, but much surplus gas remains for other economic purposes.

Composition of Gas. The following typical analyses of illuminating and fuel gas are interesting as showing the relative composition. The figures (percentages) were given by Mr. Willard L. Case in a communication to the New York section of the Society of Chemical Industry in 1905:

COMPOSITION OF ILLUMINATING AND FUEL GASES.

—	Natural gas.	Coal-gas.	Oil-gas.	Water-gas.	Carburetted water-gas.	Producer-gas from			Coke-oven gas.	Blast-furnace gas.
						Anthracite.	Bituminous coal.	Coke.		
Hydrogen	3·0	46·0	32·0	48·0	40·0	20·0	10·0	10·0	50·0	1·0
Methane	92·0	40·0	48·0	2·0	25·0	—	3·0	—	36·6	—
Ethylene	3·0	5·0	16·5	—	8·5	—	0·5	—	4·0	—
Carbon monoxide ..	—	6·0	—	38·0	19·0	25·0	23·0	29·0	6·0	27·5
Carbon dioxide ..	—	0·5	—	6·0	3·0	5·0	5·0	4·5	1·5	11·5
Nitrogen	2·0	2·0	3·0	5·5	4·0	49·5	58·0	56·0	2·0	60 0
Oxygen	—	0·5	0·5	0·5	0·5	0·5	0·5	0·5	0·5	—

Acetylene. At the beginning of the consideration of illuminating gas, acetylene was mentioned as both a combustible and luminous gas present in small quantities in coal-gas. Acetylene has, within recent years, been prepared for use by itself as an illuminant, this having been rendered possible by the discovery of a cheap method of producing it.

Action of Water on Carbides. When water is brought into contact with calcium carbide, acetylene is produced in accordance with the following chemical reaction:

$$CaC_2 + 2H_2O = Ca(OH)_2 + C_2H_2$$

calcium carbide + water = calcium hydrate + acetylene. The production of the gas is so easily and simply effected that it is no wonder that the use of acetylene soon became popular in places where coal-gas or carburetted water-gas were unattainable. Besides calcium carbide there are other carbides prepared in the electric furnace, but none of them have assumed the importance of calcium carbide. Lithium carbide, barium carbide, strontium carbide, potassium carbide, and sodium carbide, all give off acetylene when brought into contact with water, but aluminium carbide gives off methane and manganese carbide, a mixture of methane and hydrogen. [See page 3668.]

Calcium carbide treated with oil or fat is not so liable to deterioration by damp, but is still capable of slowly evolving acetylene when it is immersed in water.

Storage. On account of the action of water on calcium carbide it is necessary that it be stored from moisture—large quantities in strong iron drums, and small quantities in hermetically sealed tins. This property also accounts for the fact that the storage of calcium carbide is regulated by the Petroleum Act, except when quantities of 28 lb. in 1 lb. packages are stored.

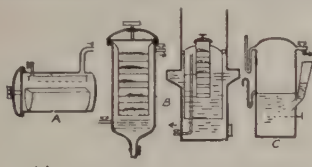
Properties of Acetylene. The light yielded by acetylene more nearly approaches sunlight in light rays, but it has more blue or violet rays (chemical rays). The illuminating power of acetylene as compared with coal-gas varies with the type of burner employed. In a suitable burner, 5 cubic ft. of acetylene per hour will give 240-candle power, while the same quantity of coal-gas gives 16-candle power. Acetylene is, however, generally burnt in small burners using from ½ cubic ft. to 1 cubic ft. per hour, when the illuminating power is from six to ten times as great as that of coal-gas. There is less heat developed by combustion of acetylene for given yield of light than most other illuminants. The distinctive smell of commercial acetylene makes it easy to detect leaks. The limits of explosibility of acetylene mixed with air are 3·1 per cent. to 24·1 per cent., which is a slightly wider range than other combustible gases of commerce. The effects of an explosion would probably be no greater than with ordinary gas. Compressed acetylene is dangerous, and its manufacture, importation, or storage at greater pressure than 100 in. of water is illegal in the United Kingdom. Acetylene is, however, allowed to be compressed along with oil-gas; and the exemption extends also to acetylene compressed into porous material, both with or without acetone. The last-named liquid has a remarkable power of absorbing acetylene, the liquid being known as *dissolved acetylene.* A cheaper solvent is acetaldehyde. Other uses are for autogenous welding, and in self-starting devices for motors.

Impurities in Acetylene. It is the impurities in acetylene which give the gas its unpleasant smell, hence every care needs to be exercised to use only pure ingredients in making calcium carbide. Phosphorus compounds in the lime used become calcium phosphide, which, when moistened with water, yields phosphine; this gives not only an unpleasant odour but also a white haze of ammonium phosphate in the air when burnt in a closed room. The highest proportion of phosphine ever met with has been 2·3 per cent. Sulphur compounds are seldom present, but sulphuretted hydrogen may be detected in cases where the gas has been improperly generated or where aluminium sulphide is present in the carbide. Crude acetylene always contains ammonia, which arises from the aluminium or calcium nitrite in the carbide. It is an objectionable impurity, as it corrodes the brass fittings, and, producing pyrol at the burners, stops them up. Traces of hydrogen silicide, oxygen, nitrogen (or air), hydrogen, carbon monoxide, and

methane, have also been found in varying small amounts.

Purification of Acetylene. The substances which have been proposed as chemical purifiers for acetylene are (1) ordinary ferric hydroxide, as used for coal-gas; (2) heratol, a solution of chromic acid in acetic or sulphuric acid absorbed in kieselguhr; (3) acagine, a mixture of bleaching powder, with 15 per cent. of lead chromate; (4) puratylene, a mixture of bleaching powder with calcium chloride and calcium hydroxide; and (5) frankoline, a solution of copper and iron chloride absorbed by kieselguhr. These materials have been subjected to an examination and tested for efficiency by Keppeler, and were, as a result, placed in the following order: Ferric acid is practically useless, but one kilo of the other four materials purifies the following quantities (in litres) of acetylene; heratol, 5,000; frankoline, 9,000; puratylene, 10,000; acagine, 13,000. In practice, these numbers may be increased from 10 per cent. to 20 per cent.

Types of Generators. There have been up to the present time some hundreds of different apparatus [11] constructed for the purpose of generating acetylene from calcium carbide. These have been classified by Professor V. B. Lewes into the following three classes, into one or other of which all the generators at present on the market fall.



11. TYPES OF ACETYLENE GENERATORS

1. Those in which water is by various devices allowed to drip or flow in a thin stream on to a mass of carbide, the evolution of the gas being regulated by the stopping of the water-feed.

2. Those in which water in volume is allowed to rise in contact with the carbide, the evolution of the gas being regulated by the water being driven back from the carbide by the increase of pressure in the generating chamber.

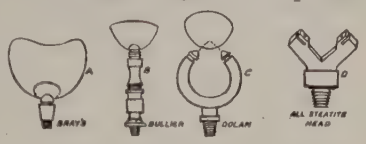
3. Those in which the carbide is dropped or plunged into an excess of water.

These types are again subdivided into (*a*) *automatic* and (*b*) *non-automatic*.

By automatic generators are meant those which have a storage capacity for gas less than the total volume which the charge of carbide is capable of generating, and which depend upon some special contrivance for stopping contact between the water and carbide. Non-automatic generators are those in which a holder of sufficient capacity is provided to receive the whole of the gas made from the largest charge of carbide which the apparatus is capable of taking.

Choosing a Generator. The factors to consider in choosing a generator are those which guided the Departmental Committee appointed to advise the Explosives Inspectors in 1900. The Committee consider that in selecting an acetylene generator regard should be had to the following desiderata: (1) simplicity of action and design; (2) strength of construction; (3) high efficiency, as indicated by the yield of gas per lb. of carbide; (4) low pressure in generator; and (5) facility of removal of the residue.

Acetylene Burners. One of the chief difficulties in the burning of acetylene is the quantity of smoke which is produced, which causes endless trouble by growths of carbon which form at the tips of the burners. Burners using 0·75 cubic ft. to 1 cubic ft. of acetylene per hour are the largest that can be used without unpleasant effects. The acetylene is mixed with air at the burner in the most successful type, an air intake being arranged at the tip of the burner. The Naphey is a popular kind. In this, two small jets of acetylene meet to form a flat flame, with very little tendency to produce smoke or become choked. Other types are shown in 12.



12. TYPES OF ACETYLENE BURNERS

Installation Hints. As there are many points of difference between the fittings used for coal-gas and acetylene, the requirements are briefly indicated separately. The generator and holder should be in a well-ventilated place outside the house, the place being capable of being warmed with hot-water pipes in case of severe weather. The holder should be of such a size as to contain sufficient gas to last the whole evening or the longest period the burners will be alight. As regards the size of the pipes used for supplying acetylene, it must be remembered that a given size pipe will supply three times as many burners with acetylene as with coal-gas. For fifteen burners ½ in. pipe is used; for sixty burners, ¾ in. Iron barrel piping should be used, and joints screwed together without paint or packing. Taps require to be of best quality brass, as cheap fittings are soon corroded. In starting an installation, care must be taken that all the air is out of the pipes. It is best to take samples of gas from each burner in a test tube, and test with a match before applying a light to the burner for the first time. The pressure at which the gas is supplied should not be more than 2½ in.

Yield and Cost of Acetylene. One pound of calcium carbide will yield 5 cubic ft. of acetylene; in practice it is usual to reckon the quantity as 4 cubic ft. Acetylene is reckoned to cost £2 per 1,000 cubic ft. in the holder, and if it is distributed on a commercial scale, the cost of distribution will double this. Coal-gas costs 1s. 2d. per 1,000 cubic ft. in the holder, this being doubled by the expense of distribution and profit. It will thus be seen that acetylene cannot displace coal-gas where the latter is obtainable.

Acetylene Lamps. Many kinds of portable acetylene lamps have been devised, but the great difficulty in the case of table lamps has been to ensure freedom from smell. It will be obvious that similar conditions and principles apply in constructing table lamps as are indicated in the case of generators. It is usual to arrange a filter of silicate wool before the acetylene is passed into the burner, so as to guard against mechanical impurities being taken into the flame. Acetylene cycle lamps are much in use on account of the brilliant illumination obtained. Such lamps are more expensive to maintain than oil lamps, and the greater light obtained is not always a recommendation. Acetylene motor lamps are a development of the cycle lamps.

Gas Meters. To measure the quantity of gas used by a consumer, gas is passed through a meter which mechanically records the volume of the gas. The meter is fixed within 2 ft. 6 in. of the main cock. The gas is measured in cubic

feet, for which, curiously enough, no standard existed till the passing of the Sale of Gas Act 1859. This Act fixed the standard cubic foot as the space occupied by 62·321 lb. avoirdupois of distilled water, weighed in air at 62° F., and at normal atmospheric pressure. Meters are tested for accuracy by passing through them a measured volume of gas from a small gasholder. The following are the capacities of a few ordinary size meters :

Size.	Size of inlet and outlet pipe.	Measuring capacity per revolution.	Per hour.
	in.	c. ft.	c. ft.
10 light	1	$\frac{1}{4}$	60
20 ,, ...	$1\frac{1}{4}$	1	120
30 ,, ...	$1\frac{1}{4}$	$1\frac{1}{2}$	180
51 ,, ...	$1\frac{1}{2}$	$2\frac{1}{2}$	300
100 ,, ...	2	5	600
250 ,, ...	4	$12\frac{1}{2}$	1,500
1,000 ,, ...	7	50	6,000

Wet Meters. There are two types of meters in use, the wet meter and the dry meter. The former is constructed on the model of the station meter, and consists of three essential parts : (1) a hollow drum or wheel rotating in water ; through this drum the gas passes, and as the drum rotates it actuates the dial index, recording automatically the gas passed ; (2) a compensating arrangement for keeping the chamber in which the drum revolves at a constant level ; and (3) the index, which shows the amount of gas passed. The measuring wheel is of inflexible material, but the water in the meter is liable to freeze in cold weather. For this reason the meter requires to be protected from changes of temperature, and as an additional precaution, glycerine is added to the water to lower the freezing-point. Salt, magnesium chloride and calcium chloride are sometimes used in place of glycerine, but corrosion of the interior of the meter often results.

Dry Meters. This type of meter works on the principle of an ordinary bellows. Gas enters and leaves compartments having flexible leather sides, alternately through valves which open and shut at the proper moment. One of the best-known makers of dry meters thus describes his make of dry meter :

It consists of a cylinder divided by a plate in the centre, into two separate cylindrical compartments, which are closed at the opposite ends by metal discs ; these metal discs serve the purpose of pistons, and they are kept in their places by a kind of universal joint adapted to each ; the space through which the discs move, and, consequently, the means of measurement, is governed by metal arms and rods, which space, when once adjusted, cannot vary. To avoid the friction attending a piston working in a cylinder, a band of leather is attached, which acts as a hinge, and folds with the motion of the disc ; this band is not instrumental in the measuring, so that, if it were to expand or contract, the registering of the meter would not be affected, inasmuch as it would only decrease or increase the capacity of the hinge, the disc being still at liberty to move through the required space ; the leather is also distributed in such a manner, being curved, and bending only in one direction, that it prevents any creases or wrinkles forming, and renders it therefore much more durable. The arrangement of the valves and arms are somewhat different to that of the steam engine, although somewhat similar in principle.

Most dry meters are composed of two chambers ; but there may be three or more, without difference of principle. The chambers fill and discharge alternately or in succession, and the action of the valves is accurately registered in the mechanism that regulates the dials of the index. A common error is the supposition that the leather enclosing the space between the discs actuates the gas ; but the whole of the work is performed by the latter, which are really pistons receding to let the gas fill the chamber and advancing to drive it out. Though delicately adjusted, the mechanical action is really very simple.

How to Read the Meter. There is no mystery about the dial of a gas meter. It is perhaps because some people have never considered the subject that they think it difficult to read a gas meter. It is as simple as telling the time by a clock. There are three or more dials in the little compartment at the top of the meter. One of these indicates, perhaps, 2 cubic ft., an arrow usually being placed to indicate the direction of the hands. When a large quantity of gas is being burnt the little hand in the unit dial is kept busy, and the consumer can get a good idea of the cost per hour of, say, a cooking stove. The other dials register hundreds, thousands, ten thousands, and million cubic feet, the hands moving on the dial just as on the smaller dial, but naturally much slower. At a given date—say, the beginning of a month—the quantity is noted, and at the end of the month the index is again read off, the difference between the two amounts being the quantity consumed during the month. In the case of illuminating devices used at public rejoicings, the gas is generally taken direct from the main and a charge made of so much per jet per hour, with a minimum charge of 50s.

Prepayment Meters. These meters, which are actuated by a coin, are also known as slot meters. They were invented in 1887, and are of various kinds—Brownhill's, Price's, Cutler's, Braddock's, Cowan's, Glover's, and Parkinson's—adapted for taking either pennies, sixpences, shillings, florins or half-crowns. The slot meter is extremely popular with people of moderate means, who can thus use a cheap illuminant without running into debt.

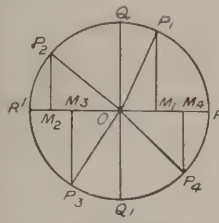
Slot-meter Mechanism. At the front of the meter is the slot. Within is a delicate balancing arrangement which works on the valve of the meter. This balance is connected with the index, and as soon as the drum cylinder has revolved the allotted number of times, the balance is disturbed, and the coin drops down, and the supply ceases. As meters are made to give out quantities of gas for a sixpence, a shilling, a florin, or half a crown, it is easy to see that the weight of the coin, except as a means of starting the action, has nothing to do with measuring the gas.

Gas-fitting. From the meter, pipes convey the gas to the various parts of the house. The supply pipes are best of wrought iron, but composition pipes are much used. The latter are more liable to damage, and many cases of leakage have been caused by nails having been driven into the softer piping. The liability to compression and consequent constriction in the supply of gas is another fault often found with composition pipes. Cheap piping is to be avoided, as soundness is a very necessary quality in gaspipes. All lines of piping should be laid with a gradient, so that condensed moisture can drip or drain back into the risers. Drip pipes should be provided where necessary. Piping should be exposed as much as possible to facilitate future examination, and where the pipes are laid beneath floors, the boards should be screwed and not nailed down. In searching for leaks in pipes, a light should not be used, but the suspected parts painted with a strong soap solution; bubbles will show themselves if the least trace of gas is escaping. The work of the gasfitter has been described on page 5369.

Definition of the Ratios. Relations Between Ratios of the Same Angle. Changes in Magnitude of the Ratios.

TRIGONOMETRICAL RATIOS

8. The Trigonometrical Ratios. Suppose an angle of any magnitude A [see note, Art. 4] to be traced by the revolution of OP from the initial position OR. Draw QOQ′ at right angles to ROR′. Unless the angle A is an exact number of right angles, the revolving line must take up some position in one of the four *quadrants* ROQ, QOR′, R′OQ′, Q′OR. In the figure, four different values of A are shown, corresponding to the four positions P_1, P_2, P_3, P_4 of P.



Draw PM ⊥ to OR. Then OM is the projection of OP on the initial line, and MP is equal to the projection of OP on OQ (which makes + 90° with the initial line). From the three quantities, OP and its projections, we can form *six* ratios. These ratios are of great importance in treating of the angle A, and each has a separate name.

(1) The ratio of MP to OP is called the *sine* of the angle A.

(2) The ratio of OM to OP is called the *cosine* of the angle A.

(3) The ratio of MP to OM is called the *tangent* of the angle A.

The remaining three ratios are formed by inverting the first three. Thus,

(4) The ratio of OP to MP is called the *cosecant* of the angle A.

(5) The ratio of OP to OM is called the *secant* of the angle A.

(6) The ratio of OM to MP is called the *cotangent* of the angle A.

The *order of the letters* in the above ratios must be carefully noted, since OM and MP stand for the projections of OP on OR and OQ respectively, and *these projections vary in sign according to the quadrant in which* OP *lies.* For example, if A is an angle lying between + 5 right angles and + 6 right angles, the revolving line will be in the second quadrant, such as OP_2, and its projection OM_2 is then *negative* [Art. 7]. The cosine of the angle A is then $\frac{OM}{OP}$, *i.e.*, a *negative* quantity, by the algebraic rule of signs.

The six ratios thus defined are called the trigonometrical ratios of the angle A. They depend only on the magnitude of A, and not on the length of OP. For if OP were taken of a different length, the new triangle, OPM, would be similar to the old one, and therefore (*Prop.* 56) the ratios of the sides would be the same as before.

9. Instead of "sine of the angle A," etc, we speak of sine A, cosine A, and so on; while, in writing them, we abbreviate them into sin A, cos A, tan A, cosec A, sec A, and cot A respectively.

10. From the above we see that to obtain the ratios of any given angle we take any point in either of the arms containing the angle, and draw a perpendicular from that point to the other arm, produced if necessary. The beginner will do well always to try and imagine that the arm to which he draws the perpendicular is in the position OR of the figure to Art. **8**; he will then have no difficulty in seeing in which quadrant the other arm must lie, and, consequently, whether OM and MP are positive or negative.

11. Note that the ratios of an angle are mere *numbers*, or *fractions.* We may therefore have any *power* of a ratio. For example, the third power of sin A would be $(\sin A)^3$. This is always, for convenience, written $\sin^3 A$. Again, such an expression as cos A . tan B means the *product* of the cosine of angle A and the tangent of angle B.

12. Relations between the Ratios of the same Angle. From the definitions of Art. **8** it is evident that

$$(1)\quad \sin A = \frac{1}{\operatorname{cosec} A}.$$

Similarly,

$$(2)\quad \cos A = \frac{1}{\sec A},$$

and

$$(3)\quad \tan A = \frac{1}{\cot A}.$$

Also,

$$(4)\quad \tan A = \frac{MP}{OM} = \frac{\frac{MP}{OP}}{\frac{OM}{OP}} = \frac{\sin A}{\cos A};$$

and, therefore,

$$\cot A = \frac{\cos A}{\sin A}.$$

By referring to the figure of Art. **8** we have, from *Prop.* 34,

$$OM^2 + MP^2 = OP^2.$$

Hence,
$$\frac{OM^2}{OP^2} + \frac{MP^2}{OP^2} = 1;$$

or,
$$\cos^2 A + \sin^2 A = 1.$$

Dividing both sides of this equation by $\cos^2 A$, and using (2) and (4) we get

$$1 + \tan^2 A = \sec^2 A.$$

Similarly, dividing by $\sin^2 A$, we get

$$\cot^2 A + 1 = \operatorname{cosec}^2 A.$$

13. The five results just proved must be committed to memory—namely,

(1) $\sin A = \dfrac{1}{\operatorname{cosec} A}$.

(2) $\cos A = \dfrac{1}{\sec A}$.

(3) $\tan A = \dfrac{1}{\cot A}$.

(4) $\tan A = \dfrac{\sin A}{\cos A}$

$\cot A = \dfrac{\cos A}{\sin A}$.

(5) $\sin^2 A + \cos^2 A = 1$

$1 + \tan^2 A = \sec^2 A$

$1 + \cot^2 A = \operatorname{cosec}^2 A$.

It is generally convenient, in proving an identity, to express the other ratios in terms of the sine and cosine, by means of these relations.

EXAMPLE. Prove that

$$\frac{\cot A + \tan B}{\tan A + \cot B} = \cot A \,.\, \tan B.$$

The expression on the left

$$= \frac{\dfrac{\cos A}{\sin A} + \dfrac{\sin B}{\cos B}}{\dfrac{\sin A}{\cos A} + \dfrac{\cos B}{\sin B}} = \frac{\dfrac{\cos A \cos B + \sin A \sin B}{\sin A \cos B}}{\dfrac{\sin A \sin B + \cos A \cos B}{\cos A \sin B}}$$

$$= \frac{\cos A \sin B}{\sin A \cos B} = \frac{\cos A}{\sin A} \times \frac{\sin B}{\cos B} = \cot A \,.\, \tan B.$$

The working of such examples should cause no difficulty if the five formulæ are well known, and if it is remembered that sin A, etc., are *numbers—i.e.*, that the example is simple *arithmetic*.

14. The five relations between the six trigonometrical ratios proved in Art. **12** enable us to express any five of the ratios in terms of the sixth.

EXAMPLE. Express the other trigonometrical ratios in terms of the tangent.

From (5) we have

$$\sec A = \sqrt{1 + \tan^2 A};$$

$$\therefore \cos A = \frac{1}{\sqrt{1 + \tan^2 A}}.$$

Hence,

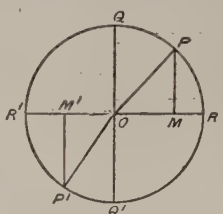
$$\sin A = \sqrt{1 - \cos^2 A} = \sqrt{1 - \frac{1}{1 + \tan^2 A}} = \frac{\tan A}{\sqrt{1 + \tan^2 A}};$$

$$\therefore \operatorname{cosec} A = \frac{1}{\sin A} = \frac{\sqrt{1 + \tan^2 A}}{\tan A}.$$

Also, from (3) $\cot A = \dfrac{1}{\tan A}$, so that the other five ratios are now expressed in terms of tan A.

15. Changes in the Magnitude of sin A. As A increases from 0° to 360° the magnitude of sin A changes. Let OR be the initial line, and let OP trace out the angle A. Suppose ROP is one value of A. Draw PM ⊥ to OR. Then $\sin A = \dfrac{MP}{OP}$.

Now, when A = 0°, OP coincides with OR, so that MP is zero. Thus, when A is 0°, sin A is 0. Again, when A = 90°, OP and MP both coincide with OQ, which is equal to OR. Hence, when A is 90°, sin A $= \dfrac{OQ}{OQ} = 1$. Also, as A *continuously* increases from 0° to 90°, *i.e.*, passes through *every* possible value between 0° and 90°, the length of MP continuously increases from zero to OP; so that $\dfrac{MP}{OP}$, *i.e.*, sin A, continuously increases from 0 to 1.



In exactly the same way we see that as A continuously increases from 90° to 180°, sin A continuously decreases from 1 to 0.

Next, as A increases between 180° and 270°, the revolving line passes through such positions as OP′. Evidently M′P′ is now negative, and since OP is always positive we have $\dfrac{M'P'}{OP'}$ negative; *i.e.*, as A increases continuously between 180° and 270°, sin A continuously decreases from 0 to −1.

Similarly, as A continuously increases from 270° to 360°, sin A continuously increases from −1 to 0.

Hence, *the sine of an angle can never be greater than* + 1 *and never less than* − 1.

16. Changes in the Value of cos A. The student can now verify for himself that as A increases from 0° to 90°, cos A decreases from 1 to 0. As A increases from 90° to 180°, cos A decreases from 0 to −1. As A increases from 180° to 270° cos A increases from −1 to 0. As A increases from 270° to 360° cos A increases from 0 to 1.

Hence, *the cosine of an angle can never be greater than* + 1 *and never less than* − 1.

17. Changes in the Value of tan A. Referring to the figure of Art. **15**, when A is 0°, MP is zero, and OM is equal to OP. Therefore tan A, or $\dfrac{MP}{OM}$ is zero. As A increases between 0° and 90°, MP continuously increases, while OM continuously decreases, hence, $\dfrac{MP}{OM}$ continuously increases. When A approaches 90°, OM becomes infinitely small, until, when A is 90°, $\dfrac{MP}{OM}$ becomes OP divided by an infinitely small quantity, *i.e.*, tan A is an infinitely great quantity. Thus, between 0° and 90°, tan A increases continuously from 0 to ∞.

Similarly, between 90° and 180°, tan A decreases from ∞ to 0. Between 180 and 270°, tan A decreases from 0 to −∞. Between 270° and 360° tan A increases from −∞ to 0.

H. J. ALLPORT

A Survey of the Chief Natural Economic Regions of the World and their Place in the World's Commerce. India's Trade.

NATURAL WEALTH OF NATIONS

HAVING studied the distribution of the chief natural commodities we must now turn our attention to the economic conditions of different countries. Commerce depends on one person or people producing more than they want of something which another person or people do not produce, or produce in insufficient quantities. The excess or defect of production may be due to natural conditions or to the stage of economic development of a people. For instance, most plants are confined to a particular zone—cotton, sugar, and coffee to the warm, tropical and sub-tropical zone, oats to the cool temperate zone. Again, coal is exported from Britain to the Baltic because there is practically no coal quite near the Baltic coast; but coal is exported from Britain to China, not because there is no coal in China, but because the vast coalfields there have not yet been properly opened up. It will be useful, therefore, to consider how countries may be grouped according to their natural products, taking into consideration the economic conditions of their inhabitants.

Zones of Different Natural Products. The first broad distinctions are between the hot or tropical, the warm or sub-tropical, the cool or temperate, and the cold or Polar lands. In each belt varieties occur according as the rainfall is heavy, moderate, or very scanty. The natural vegetation gives the key to these different divisions, and the products of each type of forest, grassland, or desert are discussed in previous articles of this course.

The Chief Trading Countries. In our own country, in most of Europe, North America, and European colonies, modern methods of cultivation, of transport and commerce have been introduced. Stock-raising, fishing and agriculture are carried on for the market, and the working of minerals and the development of manufactures are developed on a large scale. These countries may be further subdivided into two groups—those importing food and raw materials and exporting manufactured articles—such as Central and Western Europe and Eastern North America; and those largely exporting natural and cultivated products, and importing manufactured goods, such as Eastern Europe and European settlements in warm and cool temperate zones.

The Eastern Awakening. In Japan, China, and India, the soil is even more carefully cultivated than with us, but metal-working and manufacture by modern methods on a vast scale have only recently been introduced. The trade of these countries resembles that of the group last considered in that they still export natural products and import manufactures. The methods of agriculture are laborious, labour-saving machinery is little used, products are grown mainly for home use, manufactures and metal-working may be described as domestic, for the factory system has only recently been introduced. Japan is at present the most advanced of these countries, but India and China are following it.

The Poor Lands of the World. The poor lands around the Poles and the desert margins have too little natural wealth for exportation on a vast scale, but here and there, where rich mineral deposits occur, such as gold in Klondike, or where irrigation can be practised, as in Russian Central Asia, a dense and busy population is concentrated in districts usually of limited area. The lumber, etc., of the forest [pages 5297-8] and the animal wealth of the seas [page 5311] are the chief other commodities. The trade is one of export of natural products or minerals more or less worked up in exchange for manufactures.

The Rich Hot Lands. The rich grasslands of the hot belt have a denser population engaged in agriculture, pastoral pursuits, and even domestic manufacture. A considerable local trade is developed. Their exports are mainly natural products, for which manufactures are taken in exchange. They differ from the poor lands in possessing vast possibilities, and here and there, under European stimulus and supervision, are producing on a large scale—for example, bananas in the West Indies and cotton in most of the area.

The hot wet forests are much more backward. There is little agriculture or even domestic manufacture. The spontaneous products such as rubber, oil palm, coconuts, are exported in exchange for light cloth, hardware, and firearms. In the distant future these forests may become invaluable sources of supply of vegetable foods and raw materials.

The Study of Economic Geography. The first question to ask in studying commercial geography is what are the natural conditions of a country, its vegetation, its animal products, its mineral wealth? Next come considerations of density of population—how far the country can support the people, how far routes are opened up to allow its districts to communicate with each other and with other lands. These points have already been dealt with in the general geography.

The next consideration is the commerce of the land—how far it has commodities to export, and how far it must obtain necessaries and luxuries from outside its boundaries. From the outset the student is strongly advised to make use of statistical publications. It is not necessary to remember the detailed figures, but it is important to grasp the relative importance of the different exports and imports, and to try to understand what they mean geographically.

In the following sections such statistical tables will be freely used at first, and their significance pointed out, so that the student may become familiar with the examination of such tables for the purposes of commercial geography. Later, when he is thoroughly practised in this, it will not be so necessary to print many tables, but merely to refer the student to them in such annuals as the "Statesman's Year Book," the "Daily Mail Year Book" or "Whitaker's Almanack."

It is easiest to begin with the simpler conditions of the lands last mentioned, and to end our survey with the economic activities of the complex modern states of European peoples and their descendants.

THE COMMERCIAL HIGHWAYS OF THE WORLD

The ocean route distances are given in *statute* miles (69=1°) instead of the more usual *nautical* miles, or knots (60=1°), so that they can be correctly compared with those of the transcontinental routes.

Brazil as a Type of Tropical Lands. Let us select Brazil as one type of the hot, wet forest area, with open woods in the higher lands, and also at lower elevations, where it lies farthest from the equator. Some recent export figures are:

EXPORTS	Quantities		Values	
	1911	1912	1911	1912
	Bags.	Bags.	£	£
Coffee	11,257,802	12,980,303	40,401,206	46,558,079
	Kilos.	Kilos.		
Rubber	36,547,000	42,286,000	15,057,015	16,095,025
Yerba maté ..	61,831,000	62,880,000	1,983,209	2,102,568
Leather	31,931,000	36,255,000	1,798,781	2,011,820
Cocoa	34,994,000	30,168,000	1,641,381	1,529,842
Tobacco	18,489,000	24,705,000	965,357	1,434,371
Cotton	16,647,000	16,773,000	978,998	1,037,395

These may be divided into spontaneous and cultivated products. The most important of the natural products is rubber from the great forest, which has merely to be collected. The savanas yield grass for cattle, hides and skins come from the pastoral higher lands, especially of the south. Brazil has, however, many plantations the products of which are chiefly the alkaloid beverages—cocoa in the warm, wet parts of the north-east; coffee, mainly on the hills near the tropics, and yerba maté, or Paraguay tea, from the south. Finally, cotton, the fibre most used for clothing in the tropics, is grown in the north-east, but comparatively little of it is manufactured in Brazil. [See also page 3407.] In exchange for these, Brazil imports:

IMPORTS	1911	1912
	£	£
Machinery, apparatus, and tools. .	5,842,000	7,332,000
Iron and steel manufactures ..	5,473,000	6,851,000
Wheat and wheat flour ..	4,438,000	5,349,000
Cotton goods	4,905,000	4,044,000
Coal	2,788,000	3,846,000
Wine	2,362,000	2,601,000
Chemicals and drugs	1,242,000	1,455,000
Codfish	1,180,000	1,660,000
Kerosene and mineral oils ..	777,000	1,167,000
Jerked beef	967,000	936,000

As Brazil has so few factories, these are mainly manufactured goods. The next important class consists of products of the temperate zone and fish for food. Coal is required for railway, manufacturing, and domestic purpoess.

The Belgian Congo. The Belgian Congo [see page 3769] is another example of a country with like geographical conditions, but somewhat different economic ones. Its exports are as follow:

Rubber, £1,380,735; white copal, £255,394; ivory, £222,073; palm nuts and oil, £166,029; cocoa, £44,600. In addition, the exports of crude copper amount to £164,612, and of gold to £132,888.

Here is a land more recently opened to European influence. Spontaneous products of the forest play an all-important part, and cultivated plants yield but a small proportion of the total exports. The imports to the Congo are equally suggestive:

Foodstuffs and drink, £711,000; cotton tissues, £387,000; metals and metal manufactures, £294,000; machinery, £227,000; and clothing, £148,000.

Here the white man is even more dependent than in Brazil on supplies from Europe, whence practically all food and clothing are brought.

Typical Islands of the Hot Belt. Now let us take two islands where the systematic exploitation of the soil has progressed much farther than in tropical Africa or South America. From Cuba, in the West Indies, the exports for 1912 amounted to £30,580,685, of which sugar furnished 64 per cent. and tobacco 20 per cent. Of the remainder, fruits (pineapples and bananas) and iron ore are the most important. Timber is also a valuable export, the principal species being cedar and caoba.

The United States offers a ready market for the sugar, which is by far the most valuable crop, and takes about 84 per cent. of the exports from Cuba.

Tobacco, one-third as valuable as sugar, and in the form of Havana cigars, is sent all over the world, but especially to Europe and the United States.

In Java, in the East Indies, the chief exports are sugar (£11,184,000), tobacco (£3,409,000), tin (£2,776,000), coffee (£2,087,000), tea (£1,945,000), copra (£1,535,000), tapioca, pepper, rice, kapoc (used in upholstery and for making life-belts), and rubber. In both islands cultivated products far outweigh spontaneous ones in importance.

Possible Products of the Intertropical Zone. We may take the products of these islands as typical of the kinds of commodities which may be expected to be produced in larger and larger quantities from this intertropical region. In return, textiles, especially cotton, machinery, and hardware, and iron and steel goods of many kinds, luxuries of food and drink, especially wines, spirits, and beer, are imported, mainly from Europe and North America, but also from Japan, and, in the case of cotton, from India.

The commercial importance of this area may also be estimated by the population. The total number is comparatively small; and when we consider the stage of civilisation of large numbers of these people, we realise how small their powers of production and their demands for consumption must be.

Yet much land in the hot zone is fit for such cultivation as is practised in Cuba or Java or parts of Brazil. The total area of the hot belt is about half of the area of the globe. There are parts of this hot belt towards its margins, such as India and the south of China, which are well cultivated and densely peopled. The economic conditions of these old culture lands deserve a closer study.

The Lands of Southern and Eastern Asia. The eastern monsoon lands are partly intertropical and partly subtropical. The more sparsely peopled mountainous areas of South-east Asia may be classed with the regions just described. India and China, however, with their dense populations, require further consideration. In both there are vast fertile lowlands, which receive periodic rains in summer. Much of these lowlands is flooded annually, so that a layer of fresh soil is left which repairs the loss of fertility due to the crops of the previous season. There is, however, a great climatic difference between the two. India is hot at all seasons. Most of China has a well-marked winter, which is particularly severe in the north. This limits the period of cultivation in Northern China, and excludes all crops which cannot stand frost or are not annuals. Let us examine more closely the economic conditions of India. Before doing so the student should read again the remarks on pages 2525-2530.

Economic Regions of India and Ceylon. From an economic point of view we may divide India into the following districts: 1. The north-western mountainous land of Kashmir, pro-

ducing wool. 2. The north-eastern mountainous land of the Eastern Himalayas and Assam, with many tea plantations on the mountain slopes, and also with sal and other timber trees. Some rubber is collected in the lower Assam forest. 3. The irrigated Punjab, with wheat, millet, sugar-cane and some pulses. 4. The united provinces of Agra and Oudh, which form a transition from 3 to 5. 5. Bengal, the wettest and most fertile of the northern lowlands, producing rice, sugar-cane, opium, indigo, and jute in the deltaic region. 6. The Sind desert, with sheep, goats, and camels, yielding wool and hair, and also cotton in irrigated places. 7. The Northern Deccan, with cotton, wheat, millet, and oil-seeds. 8. The Central Deccan, with cotton, millet, oil-seeds, pulses, and sugar-cane to the south in Mysore. 9. The west or Malabar coast, producing cotton in the lowlands, sugar in the north, in Kathiawar, and teak on the forested slopes. 10. The east or Coromandel coast, producing cotton, palmyra palm-sugar, tobacco, in addition to millet, oil-seeds, and ground nuts. 11. Ceylon, with coconut groves round the coast, rubber plantations and ricefields on the lowlands, tea, cinchona, and cocoa on the hillsides, and rich plumbago or graphite mines. 12. Upper Burma, with teak forests and ruby mines. 13. Lower Burma, with ricefields, teak, and petroleum.

Exports of India. To Karachi, mainly by lines of the Indus basin, are sent wheat from the Punjab and some cotton and oil-seeds. Bombay receives from lines along the coast and descending from the Deccan the great supplies of cotton from Gujerat and the black cotton area of the plateau, whence come oil-seeds, opium, and wheat. It also exports cotton yarn and piece-goods from Bombay mills. The lines of the wider eastern coastal plains of the Northern Deccan converge on Madras, where cotton, oil-seeds, and rice from the easily flooded deltaic lands are exported. The greatest port of India is Calcutta, with the immense fertile plains of the Ganges and the hilly lands of Assam as hinderland. Hither opium is brought for exportation, and great supplies of jute, jute manufactures, rice, oil-seeds, and wheat. The plains of Burma furnish the rice and the hills the teak, which are exported at Rangoon.

Of the imports into India nearly 38 per cent. pass through Calcutta, 36 per cent. through Bombay, 10 per cent. through Karachi, 8 per cent. through Rangoon, and 7 per cent. through Madras. In the export trade, Calcutta again holds the first place with nearly 38 per cent. of the total outgoing trade; Bombay has 28 per cent.; Karachi over 10 per cent.; Rangoon 9 per cent., and Madras 3 per cent.

The Total Trade of India. The overland trade of India is small, owing to the mountain barrier, which makes communication difficult. The total seaborne trade of India, excluding Government stores and treasures, was, on the mean of the five years 1905-6–1909-10: Imports, 1,159,455,000 rupees; exports, 1,679,145,000 rupees, and re-exports, 34,665,000 rupees, while in 1912-13 imports were over 1,609,000,000 rupees, and exports over 2,458,000,000 rupees, of which less than 48,000,000 were re-exports. The overland trade is less easy to estimate accurately, but in 1912-13 was over 103,000,000 rupees' worth of goods imported and nearly 95,000,000 rupees' worth exported, mainly from and to Nepal and Kashmir. (A rupee is worth 15·4d.). The import trade of India consists of cotton manufactured goods, which are worth about one-third of the whole, and more than twice as much as articles of metal and metal manufactures, and of food and drink, which are next in importance. Machinery, railway plant, oils, clothing, and chemicals are other import items. The metals, notably absent from exports, are important among imports.

The Customers of India. From the above list it will be seen that at present the greater part of the imports can be supplied most easily from Europe, and that the exports, excluding opium to China, manufactures of cotton to China, Japan, and the East generally, and jute to wheat-growing lands as gunny bags, are products lacking in Europe. This is borne out by the table showing the origin of imports and destination of exports.

We may ask the question, How far is this trade permanent? Obviously, India can supply its people with food, but when the population is dense no food remains for export. For instance, Burma, with a far smaller fertile area, exports three times as much rice as Bengal, because the very large population of Bengal consumes most of the crop. Most of this Burmese rice goes to Japan and Straits Settlements. On the other hand, owing to the great demand for wheat in temperate lands, India produces much as a winter crop mainly for the foreign market, the cultivators living largely on millet. India has an advantage in sowing the wheat when the results of the northern temperate harvests are fairly well known.

In 1904, when the North American crop failed, the export from India was 25,500,000 cwt. Famine, however, has to be reckoned with, and the above figures may be compared with the 6100 cwt. of wheat exported to the United Kingdom in 1900. The increasing demand for raw cotton is likely to ensure an extension of cotton cultivation, while the efforts to suppress opium-smoking in China will greatly diminish the cultivation of the poppy.

VALUES OF IMPORTS AND EXPORTS IN THOUSANDS OF RUPEES, 1912-13

Country	Imports into India	Exports from India	Total
United Kingdom	1,014,411,390	606,516,255	1,620,927,645
Germany	103,033,995	284,633,145	351,667,140
United States	52,030,950	187,900,440	239,931,390
China	30,166,575	203,697,495	233,864,070
Japan	40,666,980	185,417,265	226,084,245
France	21,790,110	157,451,325	179,241,435
Belgium	30,434,175	131,350,305	161,784,480
Java	95,391,075	32,395,980	127,787,055
Straits Settlements	30,855,360	120,955,290	120,955,290
Austria-Hungary	35,275,320	72,521,520	107,796,840

India's poorness in minerals, especially in coal and iron in close proximity to each other, greatly hinders industrial development. The climate is unfavourable to great exertion in factories, and the quality of labour is not so good as at home. Hence, though wages are low, the cost of labour per yard is relatively high. Nevertheless, there is a steady increase in the number of factories and of the output of manufactured goods from India.

Ceylon. Colombo exports tea, coconuts, and graphite or plumbago. Rubber is being cultivated and will soon be important. Colombo is one of the great shipping junctions of the world, where ships from Suez in the north-west, the Bay of Bengal in the north-east, Singapore and the Far East, and Australia in the south-east, all meet.

A. J. AND F. D. HERBERTSON

Woods. Difficulties of Grain. Tools. Transferring the Design. Chip and Flat Carving. Relief and Intaglio Work. Bone, Ivory, and Horn Carving.

WOOD, IVORY, & BONE CARVING

ALL wood that is to be used for carving should be well seasoned, free from sapwood, knots, flaws, bruises, cracks, shakes, and nails, with straight grain and but little figure.

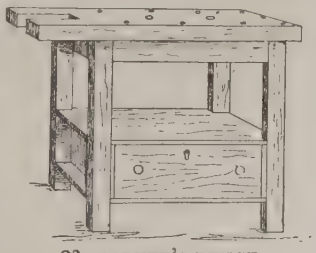
Some Suitable Woods. White deal, yellow deal, and American whitewood are soft and readily worked—too soft, indeed, for fine work, but affording capital training for the novice, who requires constant care and alertness in order to avoid accidents to himself and his material. Red deal is suitably soft, but the resins in which it is so rich clog the tools and make delicate work impossible. Plane does not split readily, and consequently can be carved into very great detail. Lime, pear, and sycamore are tougher, with nice easy grain. Kauri and Hungarian ash are both ideal woods for the carver of furniture intended for bed-room suites. Cedar is delightfully free, but very brittle. Walnut and American walnut are fairly hard, cut well, are durable, and take a good polish. Mahogany, in spite of its hardness and propensity for splintering, is not particularly difficult to carve, though the earthy salts it contains cause it to blunt tools very rapidly. Box, ebony, and cocoanut are close-grained, exceedingly hard and intractable, and only fitted for work for which unlimited time can be spared. Chestnut is tough, and rather troublesome to carve, though when finished, its colour, tone, and durability make it a formidable rival to oak.

CARVER'S TOOLS

1, 2, 3, and 4. Firmers 5. Parting tool 6. Macaroni 7 and 8. Spade tools 9. Gouge 10. Fluter or U-tool 11, 12, 13, and 14. Gouges 15 Moulder 16. Hey's saw 17. Mallet 18. Router 19. Carver's knife

The Value of Oak. Oak is universally admitted to be the favourite wood from which to fashion household and ecclesiastical furniture. The grain is a little tricky at first, but when once the carver has mastered its peculiarities, he will prefer it to all others, as did his ancestors, for it was in oak that their finest church work was executed; oak dower chests held their wardrobes; oak beds, benches, and settles rested their limbs; oak beams framed their dwellings; oak rafters supported their roofs, and oak panels furnished their rooms. No other wood withstands damp so well or improves so greatly with age. Besides the above, satin-wood, maple, bird's-eye maple, acacia, cherry, rosewood, olive, apple, ash, birch, beech, teak, camphor, Brazil-wood, bamboo, sandal-wood, and ironwood are all frequently employed. [See Timber in BUILDING, pages 216-19.]

The Mystery of Grain. On examining a transverse section of any exogenous wood it is seen to be built up of eccentric layers, around an almost central axis. The outer portion of each ring is denser than the inner. A longitudinal section reveals the fact that these layers can be separated from one another, permitting the wood to split lengthways. Each layer is composed of myriads of bundles of more or less fusiform cells, the long axes pointing in the direction of the growth of the tree. When wood is cut longitudinally the tool travels evenly between these fibres; when obliquely, they have a tendency to deflect it and guide it to a course parallel with themselves; when transversely, it continually changes the rate of its penetration, according as the soft or hard portions of a layer offer little or much resistance. Herein lies the crucial difficulty of wood-carving, for each species of wood and each separate plank presents its own peculiarities, which no amount of book learning or verbal description can possibly teach, and only constant practice can enable the student to master. No training will educate the beginner to overcome the mysteries of grain so quickly and pleasantly as chip-carving; it may not be the highest form of art, but it is executed with comparative rapidity, and the carver soon has something to show for his trouble. When, later on, he attempts the more advanced styles, he will find that he has already mastered most of the difficulties that they present.



20. CARVER'S BENCH

Tools. Carvers' tools differ very materially from those used by the carpenter and joiner, for whereas the latter are wrought from one plate of steel and another of iron welded together, and are sharpened on one side, the former have a steel plate between *two* layers of iron, and are sharpened on both sides, leaving a central cutting edge. Those chiefly used are given below.

FIRMERS. Shaped like a carpenter's chisel [1].

SKEW FIRMERS. A flat-bladed tool similar to 1, but with cutting edge set obliquely [2].

SPADE FIRMERS or SPATULAS. A spade-shaped flat blade welded to a square iron shaft. The edge is set either on the flat or skew [7 and 8].

ENTERING TOOL, FLAT-BENT FIRMER, or BENT GROUNDER. The blade has a double bend near its extremity to allow it to be used below the original surface of the panel. The edge is set flat or right or left skew [3 and 4].

21. CARVER'S SCREW

22. LONG DOG

PARTING TOOL or V. The name is descriptive, the cutting edge resembling the letter V. The shaft of the blade is either straight or up-curved [5].

GOUGE. The section of a gouge is an arc. It is said to be *quick* or *flat*, according as the radius is less or more than $\frac{1}{2}$ in. An extra flat gouge is hardly to be distinguished from a *firmer*. A gouge whose blade is $\frac{1}{4}$ in. across is quicker than one with a similar sweep, but wider [9].

FLUTER, VEINER, or U-TOOL. Similar to a very quick gouge, with an acuter curve than an arc [10].

MACARONI. In several shapes, either like a half-H or a truncated V; sometimes with rounded corners, sometimes with a curved base [6].

Gouges are made with *up-curved blades*, and also with *front* and *back bends* [11, 12, 13 and 14].

CARVER'S, or NORWEGIAN CHIP KNIFE. Has a blade with edge recurved towards the point which is in a straight line with the back, the whole being fixed almost at a right angle into a stout wooden handle [19].

ROUTER. A narrow *firmer*, driven through a flat piece of very hard wood at a steep angle, the edge projecting to the depth of the intended groundwork [18].

MOULDER, SINKER, or SCRATCH. A somewhat similar contrivance made from a piece of waste steel filed to the desired profile, and driven through a bar of wood furnished with a travelling guide like that of a *bar compass* or *trousquin* [15].

MALLET. A 5-in. stonemason's mallet, or a bottle-shaped *maul* are both preferable to a square-faced tool [17].

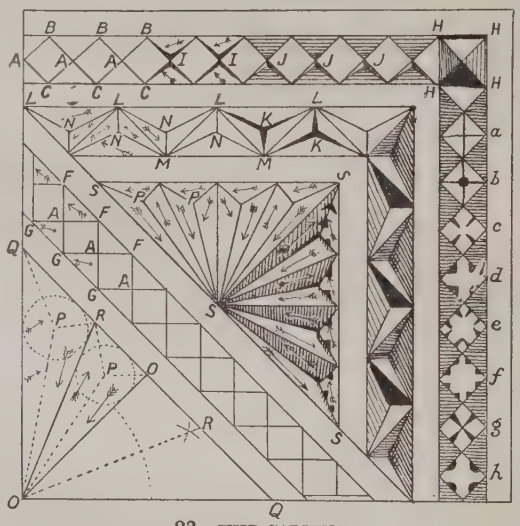
SAW. In addition to a small *tenon* and a *fret-saw*, a very useful model is that known as *Hey's saw*, such as is used by surgeons in operations upon the skull [16].

BENCH. A wood-carver's bench [20] should be very firm and heavy, with a solid top of chestnut or elm, 3 × 24 × 42 in. It should be high enough to permit the workman to rest his elbows comfortably upon it when standing. It is convenient to have it fitted with a deep drawer for tools, etc., within 9 in. of the ground. An invaluable adjunct is a good lever vice. The top should be perforated with a few holes to allow holdfasts, carvers' screws, and "long dogs" to be used.

CARVERS' SCREWS, used by screwing them into the under-surface of the panel to be carved, passing through holes in the bench, and fixing by a winged traveller. They offer no obstruction to the carver, but he must be careful to insert them opposite to some portion of the design not to be cut away, lest the protruding point should injure a cutting tool [21].

LONG DOG. A long screw furnished a-top with an iron cross-piece or *snib* [22*a*], and below with a *sycamore* nut [22].

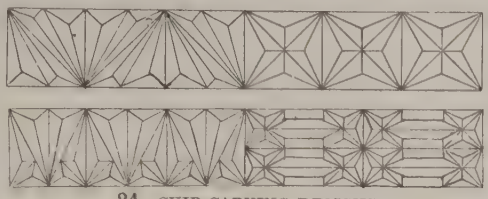
Transferring the Design to the Wood. Having determined upon the design, it must be transferred to the wood. If the carver be a good artist, he may sketch in the outline and leading features. He will find it a great assistance to rule the copy and the panel into corresponding chessboard patterns, filling in the details of the several squares; or he may superimpose a frame, strung with cross strands of silk or fine wire, above the drawing. By this simple device he can enlarge or diminish with great accuracy; or he may use a *pantograph*, or trace it with a style and carbon, calamine, blanc d'Espagne, or Prussian blue transfer paper, all of which he can easily manufacture by greasing unsized paper with spermaceti and rubbing in the required pigment. He may impress the design upon the wood with a style, pricker or tracing wheel. Time may be saved by cutting a stencil of one section of the design and stippling with thick size to which a pigment has been added. Lastly, he may paste the pattern itself upon the wood, always remembering that wet paper stretches, that wet wood warps, and that the pattern is destroyed for ever.



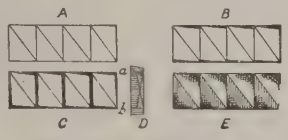
23. CHIP-CARVING

Chip-carving. The essence of chip carving, or spot carving, is that a more or less geometrical design is gradually built up by the removal of triangular or irregularly shaped chips. The following is the method of working.

Fasten a $\frac{3}{8}$-in. board of deal or whitewood, 10 in. square, flush with the right-hand corner of the bench, with the grain running right and left. Leaving a $\frac{1}{4}$-in. margin, set out a complete border of $\frac{1}{2}$-in. squares. Through each square draw two diagonals [23]. Select a skew firmer a trifle wider than half a diagonal. Grasp the handle firmly, guiding it with the left hand, till the point lies on an A and the edge along the line AB. Press the tool into the wood till the point has bitten to the depth of about $\frac{1}{8}$ in., the heel only just marking the surface. Repeat along each AB. The wood will be scored as at II. Turn the tool on its flat at such an angle that when entered along BB it will reach the bottom of the perpendicular cut by the time it reaches A. Lift out the chip BAB. The beds from which the chips are removed should appear as at JJ. Should the grain dip in places and lead the tool to bury itself too deeply change the direction of the cut from left to right. A slightly oblique thrust is less prone to be led astray by the grain than a straight forward one.



24. CHIP-CARVING DESIGNS



25. CABLE PATTERN CHIP-CARVING
A. Border *B.* First cuts *C.* Second cuts *D.* Section of second cuts through *a b* *E.* Appearance when completed

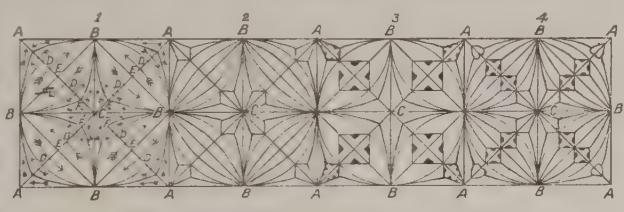
Continue till all the horizontal rows have been dealt with. Now treat the perpendicular rows similarly. Here again, avoid a straight cut; let the firmer travel diagonally across the grain, taking what advantage it can of the direction of the fibre. When all the sections have been removed, a border of flat diamonds will remain. These can be left plain, or their edges notched as suggested at *a b c*, etc.

Next attack the four corner squares. Sink from the centre to each H, and remove all the triangular sections, leaving an inverted pyramid. Or with a $\frac{1}{2}$-in. straight firmer sink along each HH; then with the skew carefully remove the top and bottom, and then the side chips, starting every time from the centre. This is rather troublesome, the difficulty being to get the edges of the pyramid regular. Leave a $\frac{1}{4}$ in. strap, and construct the diamond and straps as indicated. Remove sections AFF, AGG, working in the direction of the arrows. Set out the inner border LNM.

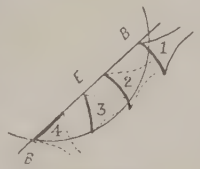
Proceed to sink as at KK. Remove all the sections, making each cut in the direction indicated by the arrows. Set out central star and four corner fans, joining each angle of a triangle to the centre of a circle inscribed within it. Sink along each of these lines, starting from P. Remove the sections as before.

Working with the Carver's Knife. Execute a similar panel on the lines suggested in 24, but work entirely with the carver's knife. A particularly effective border, known as the cable pattern, is figured in 25. Execute it with skew firmer and again with carver's knife.

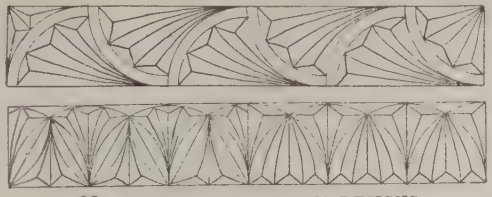
How Curves are Executed. By the introduction of circles a different knife-stroke is required. Set out a border 2 in. wide [26]. Divide it into squares AAAA. Inscribe a circle in each, joining the centres CCCC. Let fall a perpendicular BCB through each. From each centre A, at the distance AB, describe semicircles. Draw diagonals through every square. Sink the long axis BEB of each spindle BD, BD from $\frac{1}{8}$ in. deep at E to nil at BB. Remove the segments BDB with a flattish gouge, preferably a spade-shaped tool, concave surface upwards. Enter a point at B, thrust it along till it has reached E, when the direction of the cut is changed by swinging round the tool in order that its other point may finish up at the far end of the line BB [27]. Work with the arrows. Map out the rest of the design as indicated in 1, 2, 3, or 4 of 26. Whichever is selected, the segments bordering on the circumference of the circles must be removed with the concave surface of a very flat gouge, an ordinary firmer, or a knife. The variety of design is infinite, and each can be enriched with bands, fillets, grooves, veins, stippling, balls, hearts, crosses, interlacings and overlays [28].



26. CHIP-CARVING DETAILS AND DESIGNS

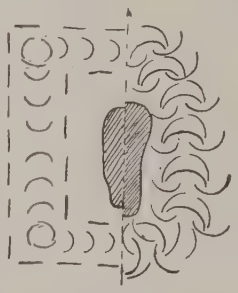


27. POSITIONS OF THE TOOL IN CHIP-CARVING CURVES



28. CURVED CHIP-CARVING DESIGNS

When under proper control, no tool is more useful to the woodcarver than the parting or V tool, which is illustrated in **5**; until thoroughly mastered, none other is so dangerous, both to the workman and his material; when blunt, none so utterly intractable. It is used in four ways.



29. GOUGE-ORNAMENTED KEYHOLES

Using the V Tool. If working in soft wood, grasp the handle firmly with the right hand, letting the butt rest in the hollow of the palm; seize the blade with the left, knuckles upward; bury one half to two-thirds of the cutting edge in the wood; push it onwards, on an even keel, keeping the same depth, guiding it with both hands, but forcing the blade onwards through the substance of the wood chiefly with the right [**33**]. Draw a few straight, curved, waved, and zigzag lines on a piece of waste wood, and endeavour to follow them with the V, ever keeping the guide-line midway between the *wings* of the tool. Next draw parallel lines at distances varying from 1-16 in. to ¼ in.

30. EXERCISE FOR V TOOL

Cut out the intervening wood, letting each wing of the V just touch the line. Next attempt circles. Beware of giving the tool a list to one side, especially when turning a sharp curve, lest the inside wing should bury itself and splinter the wood; rather press more heavily in the opposite direction. When one vein crosses another, the wood is apt to break away at the junction. Should there appear to be any danger of this happening, start the cross-cut from the point of intersection, and work away from it in either direction.

32. EXERCISE FOR V TOOL

In the second method, for delicate work, and for negotiating corners and curves, the back of the left hand is rested on the wood, the blade being guided by the thumb and two fingers, while all the pushing is done by the right [**34**].

Thirdly, if the wood be hard, the tool is grasped midway with the left hand, knuckles upward, and driven forward by repeated strokes with the mallet upon the butt of the handle, guiding the direction of the groove and regulating its depth quite as much by the impact of the blow as by the pressure of the left hand [**35**].

The blows may be given with the open palm of the right hand [**36**]. For many purposes the rapidity and delicacy of this last manœuvre cannot be excelled.

The Fluter, Veiner, or U Tool. What has just been said about the position of the hands, the employment of the mallet, and the "palm-tap" will apply equally well to the fluter, with one small exception: it is rarely advisable to sink the trough to its full depth with the first cut, unless the carver be an adept and quite certain of his touch; it is far safer to burrow out the hollow little by little, working between double lines.

Set out the border [**32**] on a strip of deal. Work

31. EXERCISE FOR FLUTER AND PUNCH

it with either tool, using the two-handed method. Set out the panel design [**30**] on a ⅝ in. oak board, carve it with the V tool and mallet. Try each with the "palm-tap." For making circular hollows with the fluter, split the wood at an angle of 45° at any point of the circumference; continue till the whole circle has been traversed and the loosened chips removed; then, with a single sweep, let the tool re-travel the whole distance, tilting it the while, that one arm may cut away the ridges which were left on its former journeys.

Drilling and Notching. For drilling small holes, such as "eyes" of leaves, hold the fluter perpendicular to the wood, rotating it rapidly between the open palms of the hands, at the same time exercising a slight downward pressure. It is

surprising how quickly a plank an inch thick can be pierced by this little manœuvre [37].

Notching is a favourite style of ornamentation, for which either the U or V is a suitable tool [10 or 5]. Drive a perpendicular cut into the wood to a depth of about ⅛ in.; then, re-entering the tool at the required distance from the convexity of the gash, let it sink deeper and deeper until the groove reaches the bottom of the first cut; a slight tilt inwards with each wing of the tool will free the chip.

33. POSITION OF HANDS WHEN USING V TOOL

The Punch. The design can be emphasised by stamping certain portions of the uncut surface with a punch [41]. Hold the punch firmly between the fingers and thumb of the left hand, in such a manner that the lower end of the tool may just free the panel; strike it smartly with the maul, that its pattern may indent the wood; rest the left wrist upon the bench, that it may offer sufficient resistance to enable the tool to recover its position between the strokes. Keep the punch constantly travelling in a haphazard, irregular fashion over the surface, since this gives a much more pleasing effect than if the indentations were parallel to one another. Do not use too sharp a tool—its duty is to punch, not to prick. Plain bands may be embellished with an occusional stamp with a circular, star, or dagger-shaped punch [42]. The keyholes of fifteenth-century chests were sometimes ornamented with patterns punched with the edge of a gouge [29]. Set out the design for an occasional table [31] on a piece of walnut; work it out with a fluter, or U tool, and four pointed punch.

34. USING V TOOL

35. THE MALLET TAP

36. THE PALM TAP

37. BORING "EYES" WITH FLUTER

38. THUMBING A FIRMER IN FLAT-CARVING

39. FORCING TOOL INTO HARD WOOD

Ambidexterity. When complete command over these tools has been attained, the student should learn to use them left-handed. The ambidextrous woodcarver has a great pull over a man who can only work right-handed; as the run of the grain varies, so can he change his tool from one hand to the other and follow it. In chip carving, especially, the time saved by not having continually to unfasten and refasten his wood, in order to turn it upside down, is very considerable.

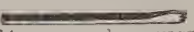
Flat Carving. Flat carving consists in cutting away certain portions of the surface of the wood, leaving the untouched parts as a raised design. Transfer the Jacobean panel [48] to a white deal board 24 in. by 11 in. Follow as much of the outline as possible with a carver's knife or skew firmer. Hold the knife in the right hand, the edge of the blade pointing in the direction in which it has to travel. Let the point penetrate the wood to the required depth. If working away from oneself, or from right to left, push it along with the left thumb, guiding with fingers of the left, and pulling in with the right hand when in a contrary direction. Avoid cutting against the grain, and follow the course of the arrows. The skew firmer may be used similarly, and with the same precaution [38], or a straight firmer, if it be tilted sufficiently to allow the front point to clear the surface.

If the wood be hard or the design complicated, the outline must be followed by selecting suitable tools to fit its varying contours, these being driven home with the mallet or forced into the wood by throwing the weight of the body forward upon them [39]. Slope the cut slightly outwards from the pattern. Frequently the margin will be found to present a rounded edge, or to show the ridge where two cuts may have overlapped. The latter may be overcome by selecting gouges of a rather flatter sweep than the convex curve to be travelled, or a trifle quicker for a concavity, and by letting each cut overlap its neighbour; the former by running a trough with a V tool within 1-16 in. of the outline. When the firmer or gouge is used later it will be found that the wood will break away into this, leaving a sharp margin on the other side. Again, when firming in the vicinity of sharp points or weak places, the tool should be entered at a wide

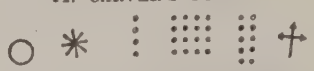
40. USING GROUNDER OR FLAT GOUGE

angle at some little distance from the outline, then nearer at a lesser angle, and so on, until the dangerous point is reached safely [45].

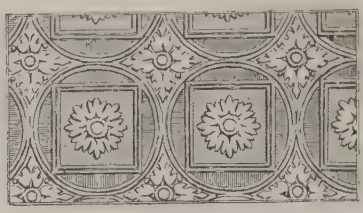
Difficulties Presented by Grain. Superfluous wood must be removed to a given depth in the intermediary spaces, which is accomplished first with quick gouges, then with flat gouges, further to level the floor, and, lastly, with flat grounders. In doing this, the difficulty of grain will again obtrude itself, for it seldom runs exactly parallel with the surface, but dips either one way or the other, leading the carver to bury his tool too deeply, splintering the wood, or undercutting the pattern. To overcome these dangers, several precautions must be taken. (1) When first fixing the panel on the bench, look at its edges and place it so that the grain may trend upwards from right to left; (2) should it be irregularly wavy, constantly change the direction of the cut to follow its upward curve; (3) use very sharp tools; (4) support the shaft of the blade with the right hand [40]; (5) always work a trifle obliquely to the grain; (6) glide the tool along with an onward and at the same time circular sweep, slicing the wood rather than making an absolutely straight cut through it; (7) make sure that the firming cuts are of their full depth, especially in the neighbourhood of weak places and sharp points.



41. CARVER'S PUNCH

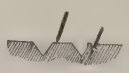


42. FACES OF VARIOUS PUNCHES USED IN WOOD-CARVING

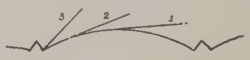


43. EXAMPLE OF DIAPER WORK

44. THE COURSE OF THE STROKE WHEN GROUNDING



45. STROKES IN FLAT CARVING



46. ROUNDING ON THE FLAT

A Much-abused Tool. The *router* [18] is invaluable for rapid grounding. Hold it tightly with both hands and push it backwards and forwards with gradually increased pressure, letting it travel over the entire ground until its flat under surface rests everywhere evenly upon the face of the panel. Finish corners, into which it cannot penetrate, with skew grounders. Most manuals decry the use of this handy little tool in no unmeasured terms. After all, it is the carver's object to remove waste wood; and though it is perfectly right he should learn to do this neatly, with very flat gouges and grounders, there is no reason why he should waste valuable time over an unimportant detail of the work which he can accomplish twenty times more quickly with the use of the router than without it.

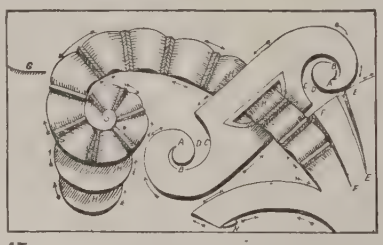
When a perfectly level floor has been smoothed out, it may be stamped with a punch to throw up the pattern into stronger relief. It was not an uncommon practice in the fourteenth and fifteenth centuries to paint or gild the ground, afterwards indenting it with geometrical designs or diapers. Occasionally it was left rough intentionally, the contrast with the polished surface of the design answering the same purpose as stamping. By bevelling the top edges of a pattern at a wide angle and slightly undercutting the bottom ones, a pleasing effect of light and shadow, suggestive also of greater depth, is gained.

Sloping a Flat Surface. The next step forward is to slope the flat surface of the pattern. In its very simplest form, folds, turnovers, and interlacements are suggested by a touch of the firmer or V tool; or it is scored with the veiner or U to simulate the veins or irregular margins of leaves; or lowered in places to imitate the appearance of an overlay.

Set out the Jacobean panel [49]. Firm the outline of the outer shield and ground out as before, following the course of the arrows [44]. Now carefully firm the inner shield, lower to $\frac{1}{8}$ in. in its immediate vicinity, then with very flat gouges gradually merge the depression into the flat surface of the design, smoothing finally with broad grounders. Sink with a flat firmer or gouge at AA to 1-16 in.; then, starting from BB, slope down to the bottom of the cut.

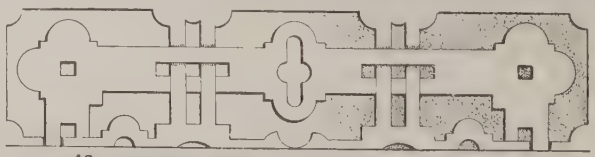
The inner line on the border of the top shield is made either with a tiny V tool or by simply scoring the surface with suitably shaped tools.

Ribbon wavings introduce another modification—namely, rounding on the flat.

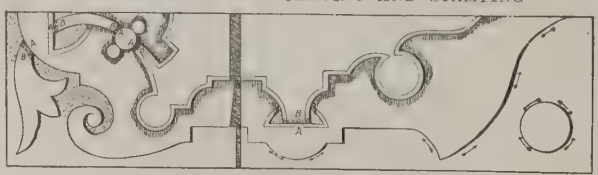


47. JACOBEAN ROUNDING ON THE FLAT

Rounding on the Flat. Transfer the design to a panel of white deal [47]. Firm the outline as far as possible with the carver's knife or a skew firmer, following the direction of the arrows.



48. JACOBEAN FLAT CARVING AND STAMPING



49. JACOBEAN SLOPING ON THE FLAT

Enter a narrow parting tool at A, let it gradually bite deeper as it follows the sweep of the volute until it reaches B, keeping it thus far upon an even keel. Now tilt it gradually to the left, that its right wing may be nearly upright by the time it reaches C. Return to B and tilt to the right, that the other wing may be almost perpendicular at D. Start from these points to firm out the rest of the scroll.

Cut E with V tool. F is only half a groove. The ribbon side must be firmed and the shape trimmed down with a very flat gouge. Ground out as before. (In the original panel the ground sinks gradually from the margin, only reaching its maximum depth of ½ in. from it, as at G.) Sink with a firmer or gouge at HHH, slope down the surface with a wide firmer, merging it into the flat. With suitably shaped gouges make perpendicular cuts in the spiral lines, starting from O. Now attack the ribbon. This can be accomplished in two ways. If the slope be with the grain, sink two perpendicular cuts where indicated, and shave down to the bottom of them with a broad firmer, starting with the blade nearly flat at the crest of the curve and getting more and more upright as it reaches the bottom of the furrow [46]. If the slope be against the grain, a macaroni can be used, or a V tool, which, after the first cut is made, can be tilted on one side and made to model down the fold in the ribbon.

Diaper Work. As the name suggests, diapers are series of repeated patterns contained in diamond-shaped compartments resembling the designs seen upon old napery. This style of wood decoration is closely allied to flat carving, and can be executed in two entirely different ways. Set out the diaper [43]. Cut perpendicularly along the outline with accurately fitting gouges; next lower the groundwork by hammering with broad, blunt punches, leaving the pattern in relief. The disadvantage of only depressing the ground and not removing it is this: wood that has been compressed will regain its former shape when moistened; thus hot water spilled on a diaper-ornamented tray would obliterate the design. If, instead of punching the ground, the pattern itself be lowered and the whole surface planed level, the design will reappear in relief if the wood be soaked thoroughly, only requiring a touch of the tool here and there to sharpen up the outline. Naturally, the relief is low, but this style of work does not readily lend itself to any other treatment. Great care must be taken to punch evenly, that the fibre of the wood may not be injured, for should this occur the pattern would not start up again when required.

50. SWEEP STROKE, FIRST POSITION

51. SWEEP STROKE, SECOND POSITION

Incised Carving. Incised work requires little technical explanation, for its details are similar to those of flat carving, from which it differs in only one particular—the design is formed by the portions removed, instead of by those which are left. To show it up more distinctly, colour can be run into the cuts with a fine brush, or they can be filled up with lacquer, and the whole scraped perfectly level and polished.

Sculpture d'Appliqué. Flat and incised carving, as well as diaper work, can be imitated easily by what is called *sculpture d'appliqué*, or applied overlays. Several thin sheets of wood are superimposed and the pattern fretted out; these pieces are next fixed in the required position with glue, the groundwork punched down, and the whole finished by paring down any rough edges that may obtrude themselves too vividly.

CARVING IN RELIEF

We now come to the most interesting of all styles of wood-carving, which consists of rounding down the surface to make it look like a natural object, whether a leaf, an animal, or a landscape.

A Panel in Relief. Set out the panel on white deal [52]. Firm the outline as usual. Ground out and complete the lozenges and ribbons. Sink the grooves BBB between the leaves to their full depth with a V tool. Leaning the tool first to one side and then the other, rough out the curved surfaces. With a flattish gouge model it still more perfectly, furnishing each leaf with a double convex contour, working all the margins to nearly ground level and letting each blend at its root with its fellows. It is better not to attempt to smooth the work piecemeal at this stage. Rather strive to get the general effect as a whole; then, and not till then, add the finishing touches with gouges that more nearly fit the curves.

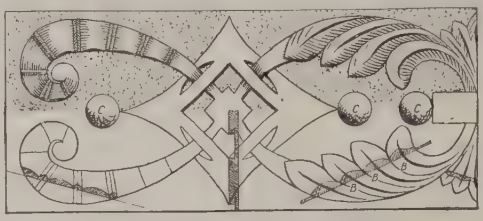
Now chip down the N.E., N.W., S.E., and S.W. corners of the balls CCC (if we may apply the term "corner" to a circular figure); next, with the concave surface of a flattish gouge, lower the wood N. and S. nearly to ground level; with a tool whose radius is nearly as quick as the circumference of the ball, round it off with a series of sweeping strokes, never making them quite in the direction of the grain, but with a forward, gliding, rotating, and ever-downward movement of the tool, so that the butt of the handle describes an upward spiral sweep.

The Carver's Freehand Stroke. It is impossible to devote too much time to the acquisition of this particular stroke, which is to the carver what freehand is to the artist. An adept will produce excellent effects with a turn or two of the wrist, while the amateur will flounder about trying to round off a figure by nibbling away at it with straight, pushing cuts. Added to this, its employment reduces the troubles caused by grain to a minimum.

Having studied the effects of the sweep stroke made with the concave surface of the tool, the reverse must be practised. Again a remarkably bold design is selected [54]. The general moulding is too well indicated to require any explanation; it need only be said that the original fifteenth-century font from which it is taken is only carved to the depth of about ⅛ in., the delusive appearance of solidity being suggested by broad bevels and slight undercuts.

The Reverse Freehand Stroke. Firm the outline and ground out as usual. Rough out the twisted leaf. Take a gouge with an arc corresponding to the curvature of the leaf, and not more than ¼ in. wide. Let the back of the tool rest nearly flat at A, A^1 [50 and 54]. Sweep it onward with a double curve that leaves the handle

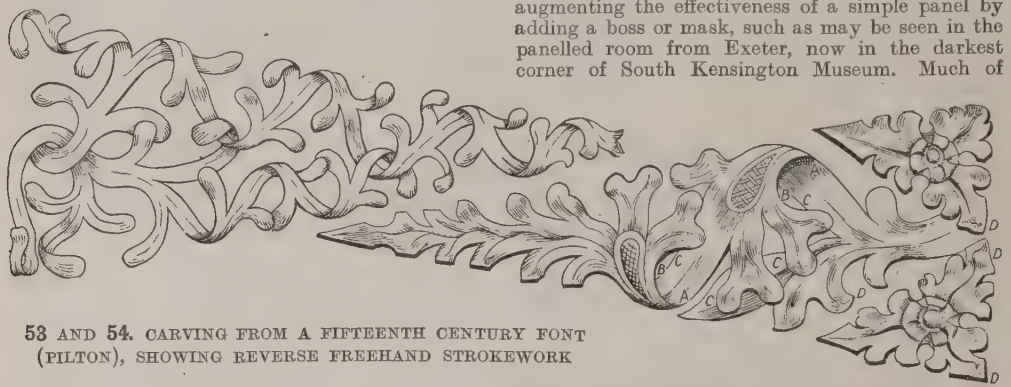
perpendicular and the blade at right angles to its first position by the time it reaches B, B^1 [51 and 54]. Do this with a continually gliding cut, so that whereas at A^1 the portion of the edge nearest the carver had most of the cutting to do, by the time it has reached B^1 it is practically free, and the other end of the blade is making the final downward cut. If too quick a gouge be used, an awkward-looking notch is left at the tail of the stroke; if too flat a one, it will probably hitch in the wood half way through the sweep. If the gouge be too small, the manœuvre will have to be repeated once or twice; if it be too large, the feat is almost impossible.



52. JACOBEAN RELIEF CARVING

such as are shown in 56, is simply a matter of combining these several methods. If a man can carve a single leaf or petal, he can, with patience, execute an entire flower. He should seize every opportunity to visit workshops, and watch how the trick is done; he will learn more in half an hour by so doing than in half a lifetime from manuals.

Modern Fakes. Relief carving nowadays is frequently "faked" by gluing a fret of the design to the panel and rounding off afterwards. This saves all the trouble of laboriously reducing a large portion of the surface to ground level. A more legitimate application of this was the practice of augmenting the effectiveness of a simple panel by adding a boss or mask, such as may be seen in the panelled room from Exeter, now in the darkest corner of South Kensington Museum. Much of the work executed by Grinling Gibbons's pupils and imitators was not true carving but *appliqué*. Many of the elaborate Devonian mantelpieces, decorated with flowers and drooping sprays, have had each leaf, stem, and flower carved separately, glued into position, touched up with putty, and finished off with paint. The French brought this style to great perfection, and adopted *sculpture à la scie* for the reduplication *ad infinitum* of floral wreaths and garlands. Further particulars will be found in "Sculpture sur Bois," one of the *Encyclopédie-Roret* series.



53 AND 54. CARVING FROM A FIFTEENTH CENTURY FONT (PILTON), SHOWING REVERSE FREEHAND STROKEWORK

Round the outside of the turnovers. Leave the edges of the leaf high, except at CCCC, where they must be lowered almost to ground level. The notches are cut with gouges held on the slant, bevelling one side and undercutting the other. Model the wavings of the leaves with gouges, noting particularly the rich double wrinkle at DD. Round off the balls, hollow their sockets, and complete by carving the bosses around them, and adding the veins with a V tool.

So all-important are these sweep-strokes that a second example has been figured with more numerous but smaller turnovers [53].

Knowledge of Clay Modelling and Shading. Should doubts arise as to how a subject should be treated, model it first in clay or Plasticine. If this be done now, it will be noticed that many of the folds in the copy are out of drawing. This is a common fault, for the carver is not always a first-class artist, and the medium he works in is not the most tractable. So useful are models at this stage that a course of modelling in clay should invariably precede that of carving in wood; the student should also be able to convert an outline drawing into a shaded study [see pages 3057 and 4909].

55. JACOBEAN PANEL MOULDING

Mouldings and Friezes. For mouldings and friezes the pattern is generally a repeat, and may run either vertically or horizontally. An easy example [55] of the former, taken from the same source as 45, 46, 47, 50, and 52, is given. The shaded portion shows the section. Run out a strip of oak with the moulding plane. Stencil the pattern on the wood. In firming the outline, the tool should always be pointed at the centre of the circle of which the face of the moulding happens to be the arc; by this means a clean edge, throwing a pleasant shadow, is ensured. At the extremities of the chord, AA, let the ground die away to the level of the surface. Vein with V or fluter. Drill the small holes with a very quick gouge as shown in 37 [page 5553]. Saw down at CC to the level shown in the section at BB, with a Hey's saw;

The More Complicated Designs. Having learned to vein, flute, firm, ground, slope, round, and turnover, the execution of more complicated designs,

round the balls and the ends of the bolsters as described. When cutting mouldings to occupy a horizontal position, this fact must be remembered when the work is on the bench. Take, for example, the familiar "egg and tongue." The sinking cuts, which are necessary to free the wood scooped from the hollow in which the egg lies, must be parallel with the horizon, and each upward sweep must meet it at right angles.

Flutings of pillars and pilasters may be carved with gouges, though it is far easier to run them out with a moulding plane or a travelling *bur*, leaving the carving tool nothing to do but to trim up the extremities of each. Spirals, which were formerly carved with gouges from start to finish, are now simply turned on a lathe.

A symmetrical twist may be easily obtained by winding a strip of paper, down the centre of which a line has been drawn, round the post to be carved, and marking the wood at its edges. Sink a furrow along this line with a V, keeping it on an even keel, and always at the same inclination to the axis of the cylinder. It is most important that this groove should be the same depth throughout if the post is of the same thickness all the way up, or taper gradually should it do likewise. Rough out the curves with flat gouges from the bottom of the furrow to the central line on the paper. Smooth with a gouge that is just a shade flatter than the curve of the spiral; this will give more play, and is less likely to get hitched than one which fits exactly.

56. PANEL IN RELIEF CARVING FROM A SIXTEENTH CENTURY ITALIAN MARRIAGE COFFER

Intaglio Work. Still another method of ornamentation is *deep, intaglio*, or *die sinking*. This is the exact reverse of relief carving, for the surface remains plain and the pattern is sunk. It is quite easy for any one who has been accustomed to relief work. The main features of the design are scooped out with bent gouges, details are added with quicker tools, and veins added last of all. It is of great assistance to the carver if he takes a squeeze of his work in Plasticine from time to time, in order to judge of the general effect. By disarranging the lighting, and causing shadows to fall in a contrary direction, a casual glance will receive the false idea of relief.

The Value of Keeping Records. Whenever possible, copies should be taken of good work. Putting on one side the obvious methods of sketching and photography, this may be done with a "squeeze." Oil the panel well, and proceed to cover it with sheets of very wet paper, pressing them thoroughly into every crevice; add layer upon layer of coarse brown-paper soaked in size or very thin glue. Squeeze out all superfluous moisture. Leave in position to set sufficiently well to permit of removal without danger. When this is dry, plaster of Paris casts can be obtained from it, or others having the appearance of wood itself by using a mixture of equal parts by weight of gelatine, wood sawdust, and phosphate of lime, moistened sufficiently to make into a stiff paste. Leather well soaked in hot water may be used, or a lump of soap, clay, or putty. Flat carvings may be "rubbed" with heelball or blacklead. This procedure is inapplicable to relief; still, a very good general idea of a panel can be obtained by the aid of a newspaper and a rather greasy rag. Press the paper down on the pattern, gently moulding it as much as possible with the fingers. On going over it with the greasy rag, the printing-ink will be smudged most wherever the relief is highest.

Work in the round is erroneously believed to be the most difficult of all styles to accomplish; in reality, it is nothing more than panels in relief carved on both sides. To minimise labour and to prepare the block, it is useful to take a profile of the copy with a strip of lead or malleable zinc. Apply this to the wood and pencil the outline. Take the opposite profile and transfer as before; then treat the sides similarly.

Carving in the Round. Remove with the saw as much of the waste wood as possible. Next whittle away superfluous material with mallet and gouge, proving progress with the metal guide or with callipers. Should any detail cause anxiety, model it over and over again, or work it out on a soft piece of wood. It is better to devote a few minutes to this than to waste the labour of weeks by perpetrating an irremediable error. Take off too little, rather than too much; superfluous wood can be removed, but additions are not so easy.

If he should be nervous about starting—and most novices are—let him begin on some ridiculously easy task, such as sharpening a pencil very neatly or carving animals such as those in a Noah's Ark. Afterwards he may try a poppy-head ornament, which he will find to be nothing but two studies of foliage in high relief placed back to back. The human figure and drapery are the most advanced style of all, just as is the case with relief, but the student will find it far easier to hack out a head or other figure-work in high relief than in low relief.

Tracery and Perforated Work. Tracery and perforated work is an advance upon fret cutting. The ground is entirely removed, leaving lights. It presents no difficulties to the good wood-carver, but it does not pay him nowadays to execute it. Modern machinery, with its lathes, planes, bits, and burs, can rip out tracery mouldings in a hundredth part of the time in which an expert workman can carve it; so with panel reduplication by mechanical means. It is wonderful to watch a species of glorified pantograph, armed with a

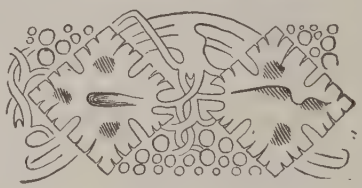
revolving bur, copy the design with hardly any manual assistance; but it is not wood-carving, and its servile imitation destroys half its charm.

Foliage. Veins of leaves are frequently carved in relief, instead of being sunk with a V tool or fluter. Twin furrows are run along with a V, leaving a medium ridge. The surface is worked down to the foot of this, which is trimmed to shape, tapered at its extremity, neatly joined at its branchings, and made to die away into the leaf stalk. The macaroni is a handy tool for this work, though it cannot be used close to a junction.

Though the flora of the wood-carver often bears but slight resemblance to that of the botanist, there are certain well-defined points common to each. Thus, veins, though showing as depressions on the upper surface of a leaf, appear as ridges below; remember this when treating a turnover. Noting the general characteristics of a plant, the student will the better appreciate the skill with which the mediæval artist selected and treated his subjects, and will see why it was that the lily, vine, thistle, oak, Passion flower, poppy, dandelion, rose, and, above all, the acanthus [57] were such universal favourites, and why the coarse and perishable nature of his material led him to limit his efforts to purely decorative adaptations.

The Vine and the Rose. The vine, not only because of its adaptability for ornamental purposes, but also because its religious symbolism, was constantly utilised in ecclesiastical architecture. The carver treated it in two distinct ways. Sometimes the leaf was inscribed within the limits of a symmetrical pentagon, its four eyes and the point of junction with the leaf stalk being arranged at the corners of a similarly shaped, but inverted, figure. At other times the leaf was placed within the area of a square or lozenge, as may be often noticed on the friezes and crochets of late Gothic work [58]. The thistle and dandelion are adapted to follow the lines of acute-angled triangles. Both are invaluable for filling in odd corners of tracery.

57. ACANTHUS LEAF DESIGN



58. VINE CARVING IN ATHERINGTON CHURCH, DEVON

Ivy falls within the lines of a pentagon, and occasionally those of an isosceles triangle.

The rose is conventionally depicted as a symmetrical five-petalled flower, each petal furnished with a fold-over having a bracket-shaped edge. A common sixteenth-century ornament was the Tudor rose, the union of the Houses of York and Lancaster being symbolised by the exhibition of both flowers in one boss, one superimposed upon the other, their petals alternating.

The Oak Leaf. Perhaps no other leaf had so many liberties taken with it by German carvers as the oak. They more than conventionalised it; they exaggerated, elongated, stunted, twisted, and folded it, till it became almost unrecognisable. They left it with widely indented margin, rectangular lobes, rugged and misshapen, stunted, gnarled, and bent like its parent tree, and yet effective and picturesque.

The acanthus [57] is a characteristic feature of Renaissance design. At first sight it appears a difficult and complicated subject, but on dissecting its structure it is found to be contained within the limits of two concavo-convex lines, which start from a common point, separate gracefully, and finally coalesce, the leaf bellying and swelling between them. This simplicity of outline is now broken by subdividing each leaf into a number of lobes, the junction of each with its fellow being marked by an "eye." Each lobe in turn is deeply serrated. A vein runs down the centre of each lobe, and pipings start from every eye, all losing themselves at a common point. Whether viewed in full or in profile, its main lines are always the same, never parallel, never crossing, but each a graceful curve radiating from a common point, and strictly subservient to an outline of the greatest beauty and simplicity.

Finishing and Ageing. It cannot be impressed too strongly upon the novice that sandpapering carved work to "make it look smooth" is an unpardonable crime. A few touches with the scraper or rubbing down with a bone are bad enough, but "papering" is the rankest of all heresies. There is nothing to be ashamed of in tool-marks, for at least they show the work is genuine, hand-wrought stuff.

To keep the carvings clean, light woods may be given a thin coat or two of "egg-shell" varnish; oak and chestnut should be treated to a soaking in boiled linseed oil, followed by plenty of "elbow-grease," using a stiff brush. Beeswax and turpentine should be avoided; they clog the corners of the work and destroy its sharpness. Most other hard woods may be French-polished.

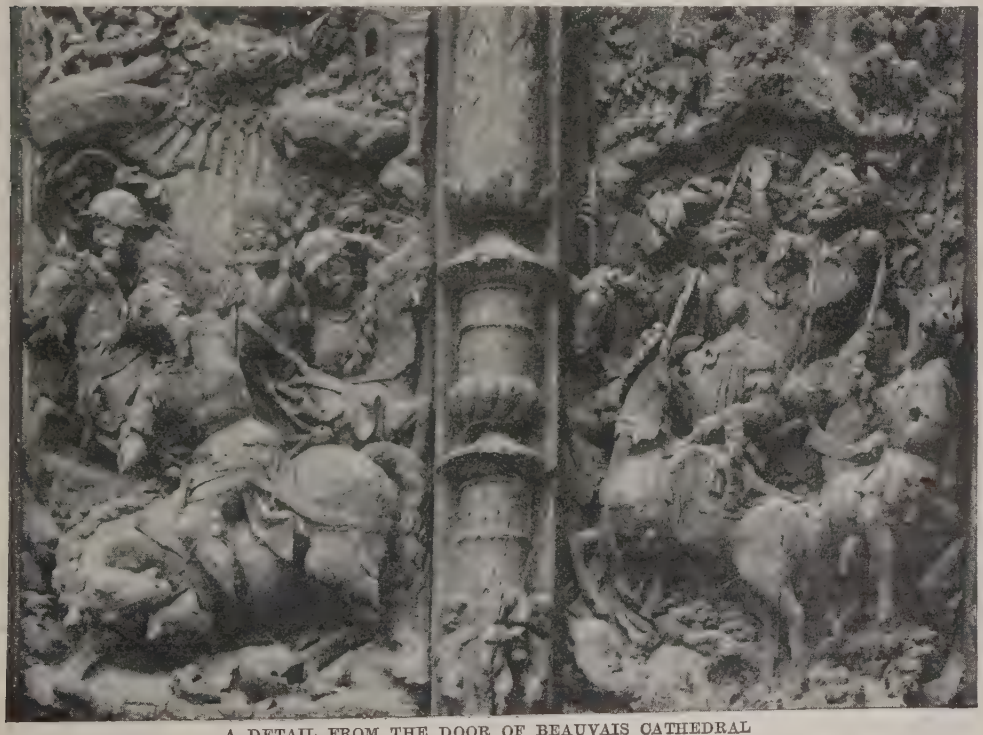
It is frequently necessary to stain new wood in order to make it match older work. Apple, pear, and box can be aged with a weak infusion of saffron; lime, ash, kauri, and whitewood with turmeric or a solution of chloride of tin; mahogany with Brazil-wood. Oak can be slowly darkened with a 2 per cent. solution of bichromate of potash to which ¼ per cent. of dilute nitric acid has been added. The process takes a few months, but the tone gained is particularly rich and warm. Veining and figure-work can be brought into strong relief by treating first with a weak decoction of madder, and, when this is dry, painting with a solution of acetate of lead.

Blue-black is attained by a decoction of oak galls, followed by a solution of green vitriol; jet black by a decoction of oak bark and then perchloride of iron; purple-black by log wood; brown-black by madder and acetate of copper.

Fuming. Oak, and other woods in a smaller degree, can be darkened very rapidly by exposing them, in an airtight box or cupboard, to the fumes of ammonia; but the weaker the dose and the longer the time allowed, the better the result. Storage for several years in a badly ventilated stable loft imparts a tone that cannot be equalled by any other method.

Wood-carvings may be preserved from the ravages of worm and rot by fumigating with calomel, formalin, or corrosive sublimate, by dressing with a solution of alum or of waterglass, or, best of all, by impregnating the panel with hard paraffin under heavy pressure at a temperature of about 180° F.

THREE FIGURES ON A DOOR AT ST. SAUVEUR CATHEDRAL, AIX



A DETAIL FROM THE DOOR OF BEAUVAIS CATHEDRAL

BONE AND IVORY CARVING

The presence of carved and engraved bones among the tertiary deposits of Europe and America constitutes the strongest link in the chain of evidence that connects man with this remote period [see pages 156 and 158].

Bone Carving. On account of the hardness of its outer layers and the cancellous structure of the inner, deep carving is not suitable to this material. Having sawn the bone into convenient slabs, rough out the design with the parting tool and very quick gouges; rough carve with flat gouges and firmers, finishing with the assistance of rifflers and files. Sandpaper then comes into play to remove scratches and tool-marks, the whole being finally polished with the help of putty powder.

Bone is easily dyed; it is even possible to impart a red colour to it during the lifetime of the animal by feeding it with madder (*Rubia tinctorum*). Bone is used as a cheap substitute for ivory for knife-handles, chessmen, thimbles, and other small articles, but it soon discolours, and the comparative coarseness of its grain renders it useless for the production of delicate objects.

Ivory Carving. The antiquity of this handicraft is also undoubted, for, like bone carving, it dates back to prehistoric ages.

Ivory is a fine-grained, hard, dentine-like substance composing the tusks of both the African and the Indian elephant, together with those of the walrus and the narwhal. The molars of the elephant yield a less dense variety, and those of the hippopotamus a peculiarly hard kind which was used by dentists. All the above are known as green or live ivory, distinguishing them from the white, dead, fossil, or Siberian ivory obtained from the remains of the extinct mammoth. The density, toughness, elasticity, durability, colour, and beautiful figure of ivory, its absence of appreciable grain, and its capacity for receiving a high degree of finish, eminently fit it for the carver's hands.

The Tools for Ivory Carving. The tools used for carving ivory are similar in character to those of the wood-carver, but smaller and stouter, with less tapered edges, like turning and engraving tools. The design is drawn upon the ivory in Indian ink, as much as possible of the surface is removed with the saw, the pattern is grounded out, and the contours roughly hacked into shape. The ordinary cutting stroke is too tedious to be of practical service. Waste is removed more quickly by holding the tool upright and advancing first one corner of it and then the other in a zigzag fashion, exerting firm pressure the while, nibbling the ivory away little by little. Drills and tiny points are next used for the deeper portions, and files for the shallower. Indeed, the file is such an important tool that "ivory filing" would be a more appropriate term for the art than "ivory carving." Ivory is more cheaply worked by worrying away its substance with revolving burs and drills.

Polishing, Engraving, and Repairing. The work is polished in three successive stages: (1) No. 0 glasspaper; (2) putty powder, pumice, or fine siliceous earth; and (3) a revolving brush fed with whiting and water. Ivory may be easily engraved, the pattern being rendered visible by rubbing in Indian ink or indigo, and papering the surface to bring up the lines clearly and sharply.

Broken ivories can be repaired with fish glue, provided the broken surfaces are not greasy, in which case cleanse them with sulphuric ether, alcohol, or benzene. Warm both fragments, apply as little glue as possible, and exert firm pressure till thoroughly set. Ivory dust or shavings mixed with fish glue may be used for building up bruises, chips, or deep scratches. Ivory carvings are apt to discolour unless exposed freely to both light and air.

Imitation and the Forgotten Moulded Ivories. Very fair imitations of old ivories may be made by covering carved wood with three or four coats of very pale chrome enamel, re-stamping the groundwork, and flooding the depressions with Vandyke-brown; or by making casts in a creamy-yellow plaster of Paris, boiling them in spermaceti or hard paraffin, stippling the ground and lining the furrows with brown, finally adding fine black, wavy strokes with Indian ink to simulate the cracks of the original.

Ivory may be made plastic by dissolving its earthy salts with phosphoric acid; on the other hand, when brittle and friable from age, it may be toughened by boiling in gelatine.

There is little doubt it was at one time possible to soften ivory so as to allow of its being squeezed or moulded into sheets of considerable size. Unfortunately, this is a lost art, for none of the recipes which have been preserved have proved successful.

Ivory Substitutes. The curiously hard seeds of the *Phytelephas macrocarpa* are used as a substitute for ivory; the absence of the characteristic "engine-turned" figure of genuine ivory at once proclaims this substitute.

An artificial ivory known as bonzoline is supposed to be a mixture of celluloid and some very fine mineral earth.

Horn Carving. Ox and buffalo horns are chiefly used for this purpose, though rhinoceros horn is occasionally ornamented as a curio. Ram's horn is so decorated by Nature that further treatment is superfluous. Horns of deer are really deciduous bones, and, with the exception of their being utilised as knife and cutlery handles, are generally better adapted as decorative objects when uncarved and arranged in pairs.

Horns may be carved with ordinary wood-carving tools, but owing to the smoothness, roundness, and natural greasiness of the surface, it is not always an easy matter to get the tool to bite. Fortunately, horn can be softened by boiling. The carver, therefore, overcomes the difficulty by letting a jet of steam play on the horn, though he has to be careful not to allow it to remain subjected to a high moist heat for long at a time, lest the natural cement which binds together the bundles of fibrous hairs of which it is constructed should be decomposed.

Working Difficulties. The carver also has to exercise considerable ingenuity in fixing his work firmly. Sometimes he will be able to keep it steady in a vice well padded with leather; at others by wedging it on both sides with wooden knees, and fixing cross-pieces above it. Or he may stand it upright and screw it to the bench, or fit the thin extremity into a block of wood or cement which can be held with a holdfast while the thick end is clamped to the table with a "long dog" [22]. By this manœuvre a quarter-face can be worked at a time. A sharp knife is capable of doing most of the roughing out.

An effective and permanent decoration is to stain the groundwork black with nitrate of silver, brown with chloride of gold, or yellow with nitric acid. Horn may be made as plastic as putty by boiling it with quicklime, in which state it can be moulded into any shape, regaining its temper on being subjected to a continuous stream of cold water.

Methods by which New Varieties are Obtained. Grafting. Budding. Layering. Germination of Seeds, and Seed-testing.

PROPAGATION OF FRUIT-TREES

ANY fruit-grower who applies himself with intelligence and zest to his task will not only want to know the regular routine work, but will take a keen interest also in the more scientific branches of the profession. Knowledge of such subjects as the methods of propagation will prove of much practical value. After painstaking study of such matters he will find, when buying, that he more easily and surely chooses the best trees for his purpose. He can tell how old a tree is, whether it has been carefully started on its career and properly tended during its growth, and thus will be able to get the very best value for his money.

The Ideal Fruit-tree. Before describing the actual operations of propagation, it will be worth while to know what is the ideal fruit-tree to be aimed at. A first-class tree is one with a stocky, strong trunk, good roots, and the union—that is, the place where the bud or graft is united to the stock—completely healed over. Stocky or rather short trees with well-branched heads are always preferable to very tall ones; very slender trees over two years old should be avoided. The bark must be clean and smooth, and, above all things, it must be free from injurious insects or fungous diseases. It must be all this before it has arrived at the proper age for planting, which, in most cases, is two years old.

There are, roughly, about seven methods by which various fruits are propagated: (1) From seeds, (2) by separation, (3) by layering, (4) by runners, (5) by cuttings, (6) by budding, (7) by grafting.

Reproduction from Stocks. In the first place, all fruits can be raised from seeds, but unless it is desired to produce a new variety this method is not adopted, as the seeds of some fruits do not reproduce fruit of the same kind as that of the tree from which they came. For instance, none of the varieties of the apple reproduce the same kind from seed. Thus there has never been more than one true Cox's Orange apple-tree grown from seed; all trees of this variety except the first one—which of necessity did come from seed and could not have come in any other manner—have been grown by inserting into other seedling stocks either buds or scions from this original tree, or from others propagated from it.

Apple-trees, then, and all fruit-trees with very few exceptions, are propagated by budding or grafting—that is, by inserting a bud or scion of the variety desired into another tree or seedling. By *seedling* is meant a small tree raised from a seed. These are technically called *stocks*. These stocks are generally obtained from France or other European countries, where, for reasons such as climate and soil, they are raised much more cheaply and satisfactorily than in England. The chief stocks are known as Crab and Paradise. Of recent years, however, there have come into favour two new stocks imported from America, known as Northern Spy and Majetin, which are supposed to be resistant to the terrible scourge of woolly aphis. These stocks are shown [70] in the nursery ready for being worked—that is to say, they have been planted and have taken hold in the soil, ready for being budded or grafted. It is essential that these stocks should be firmly planted, otherwise the tree will never be a perfect one, but will be stunted from the beginning of its growth.

The selection of stock is an important point to be considered, as the nature of the tree largely depends upon the stock used. This is well illustrated by the two photographs reproduced, which were taken at the same time, the trees being of the same age and variety of apple. The first tree [71] was worked on a Paradise stock, and is consequently low-branching and wide-spreading, and blossoms later than the second tree [72], which was grafted on a Crab stock, and is taller in its habit of growth.

The Objects of Grafting. The process of grafting consists in inserting a cutting, technically called a *scion*, of the variety desired into the stock. There are three reasons for this operation. First, by far the most usual reason is to perpetuate the variety, and practically all stocks for commercial purposes are grafted for this reason. Second, grafting is done to hasten fruiting to test a new variety. Sometimes a propagator wishes to test the value of a new variety that he may have raised from seed without having to wait a number of years, as he would have otherwise to do, before the young trees fruited. In this case, as scions from young trees bear sooner when set in old trees than when set in young trees, an old tree is generally chosen as the stock, and the graft is inserted on the branches close to the trunk, this operation being termed *top grafting* [73]. Third, grafting is for the purpose of producing a radical change of nature of scion or stock. Grafting may correct a poor habit, as in the case of the Winter Nelis pear, which is of a weak and straggling habit; it will often modify the season of ripening. This is brought about by different habits of maturity of growth in the stock and scion. A case in point is that of the Twenty Ounce apple, which has been known to ripen in advance of its season by being worked on a variety known as Early Harvest. It is said that the Roxbury russet, when grafted on the Golden Sweet, has been modified both in flavour and keeping qualities. Sometimes, too, it increases the size of fruit, as in the case of certain pears, which, when grown upon the quince stock, will bear larger fruit than on standard trees, quince stock being of a dwarf nature.

Time for Grafting. Grafting is carried out as the sap begins to rise in the trees and the buds to swell. In normal seasons this is, for plums and cherries, the first fortnight in April, and for pears and apples the last fortnight in the same month, though it naturally depends somewhat upon the season.

Choice of Scions. The first thing to do is to select the scions. These are always taken from new wood—that is, ripe wood which has grown the previous summer. They should be about four inches long, with a smooth, clean cut, and there must always be a perfect union between the scion

and the inner bark of the stock. The work should be done rapidly, so that the cut surfaces may not be exposed to the air more than is necessary, and, after the graft has been inserted, all cut parts should be made impervious to air and water.

Methods of Grafting. There are several methods of grafting, the chief of which are the whip graft, the double whip graft, splice grafting, and cleft grafting. The illustrations clearly show the difference in appearance of scions prepared according to the varying methods [**78-84**].

For nursery work that most generally in use is the *whip graft*, sometimes called tongue grafting. For a whip graft both the scion and the stock are cut across diagonally [**80-81**]. The cut surface extends one or two inches, according to the size of the part. A vertical cleft is then made in both, and the two are joined together by inserting the tongue of the scion into the cleft made in the stock. A *double whip graft* is made with two of these tongues in the scion and two slits in the stock. After the scion has been inserted it is tied round firmly with bast, and the whole is then waxed over with grafting wax [**82-84**].

Another form of grafting often used is the *cleft graft*. This is invariably used for top grafting and for regrafting old trees. The stock is cut off horizontally, and split down the centre some two or three inches. Into this is inserted a scion, cut in the shape of a wedge [**79**]. It is usual in the case of re-working old trees to insert two scions into each branch that has been cut, one into each side, as illustrated [**78**], binding and waxing as in the case of the whip graft.

70. STOCKS PLANTED IN A NURSERY READY TO BE WORKED

Splice grafting is the simplest form of grafting that is known. It is seldom used, however, except in cases where the wood is soft and tender and cannot easily be split. The stock and the scion are simply cut across diagonally, laid together, and bound round and waxed.

Scions should be used as soon after cutting as possible, but if they have to be kept it is best to put them in moist sawdust and cover them with sacking. It has been mentioned that in cleft grafting two scions are generally inserted, but if both grow, one is afterwards cut away. In re-working old trees it is advisable not to cut all the branches of the trees away at once, for by so doing the tree will be liable to receive too great a check. Some fruit-growers only cut away the branches that are actually to be grafted.

Attention After Grafting. All suckers that come out near the grafts during the summer should be removed, so that all the nutriment in the tree may go to the scions themselves. Careful watching is necessary, lest the buds should grow with too great vigour, and thereby get broken off by the wind. If there is any fear of this it would be well to pinch off the ends before any injury occurs to the scions, as, if these are once broken out of the tree, all the previous work will have been wasted.

Grafting-wax Formulæ. The following formula for grafting-wax is recommended by Luther Burbank: 1 lb. tallow, 1 lb. beeswax, 4 lb. resin. Some nurserymen prefer a wax with alcohol, which makes it more plastic. They use: 1 lb. tallow, 2 lb. beeswax, 4 lb. resin, and 2 oz. alcohol.

In making the wax, melt the beeswax, resin, and tallow. Allow the mixture to become slightly cool. Turn it out into cold water and knead it or draw it until it is tough and plastic. If the weather is cold when the wax is to be used add more tallow, but if the weather is hot more resin is desirable. If tallow is difficult to obtain, one fourth the quantity of linseed oil will answer as well.

Budding. Budding is the name given to the process of applying a single bud bearing little or no wood to the surface of the growing wood of the stock. It is performed during the month of August, when the stocks have arrived at maturity. If there is any doubt as to the trees having matured sufficiently they may be tested by peeling a little piece of the bark; if it peels off quite easily they are ready, but if it does not the operation must be postponed.

The most convenient size of stock for this purpose is one about $\frac{3}{8}$ in. in diameter. The buds used should be taken from vigorous fruiting trees that produce the type of fruit desired, and from strong, hardened shoots of the season's growth. They are obtained by cutting from an existing fruit-tree lengths of new wood, which are called *budding sticks* [**85**]. The leaves are removed, with the exception of a small part of the stalk of each leaf, which serves as a handle for using the bud, and also acts in some measure as a protection to the bud itself. The bud sticks should be kept in a moist cloth, or, better still, in a small bucket containing water.

It is the practice to remove all small twigs or leaves that may be growing on the stock for 5 or 6 in. above the level of the ground. An opening is made in the bark of the stock, which is technically spoken of as the *matrix*. This opening is made by two slight incisions, one vertical and one transverse, the outer bark only being cut. The transverse is usually the first cut that is made; the vertical cut is then made by inserting the blade about $\frac{3}{4}$ in. lower, and drawing it upwards to the cut already made [**86-87**].

Special knives are made for the work, with a thin, sharp steel blade rounded at the tip, and having an ivory or bone handle, the end of which has been bevelled off like a paper-knife. The bud is then prepared. It is taken from the bud stick, usually about $\frac{3}{4}$ to 1 in. in length being cut, as shown in the illustration [**91**]. All the wood from the back inside the bark is trimmed or gouged out [**92**]. The ivory end of the knife is used for slipping in the matrix and loosening the bark on each side of the vertical cut, so that the bud can be placed in without difficulty. The bark is then pressed home again over the bud that has been inserted, and the whole tied round

RESULTS OF GRAFTING IN FRUIT TREES

71. TREE WORKED ON PARADISE STOCK

72. TREE WORKED ON CRAB STOCK

73. TREE THAT HAS BEEN TOP-GRAFTED OR RE-WORKED

74. STOCKS CUT DOWN AND GRAFTED

75. THE SAME TREES WITH GRAFTS GROWN FOUR MONTHS LATER

76. VICTORIA PLUMS THE YEAR AFTER GRAFTING

77. A NEAR VIEW OF THE TREES SHOWN IN 76

The photographs on these pages are by courtesy of Messrs. Chivers & Sons, Histon

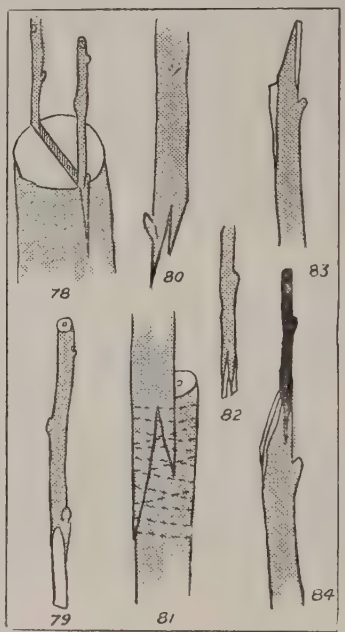
firmly with raffia [88-90]. In two or three weeks, if the raffia appears to be cutting into the swelling buds, it should be severed.

No further attention need be paid to the buds until the following spring, when in the case of those that have taken successfully [93-94] the stock is cut off immediately above where the bud was inserted. In the case of any that have not taken, the stock may be grafted.

Pruning Young Trees in the Nursery. It has been mentioned that the best trees to select are those that are stocky. Anything which tends to assist the health of the trees and to make them grow with vigour will aid in this direction. One of the first essentials is that they should have plenty of room. For this reason the rows in the nursery should be from 3 to 4 ft. apart, and the trees themselves a foot apart in the rows. The rubbing off of the leaves should not be carried out the first year, as this would cause the trees to grow too much at the top, making them tall and slender, and what is termed "leggy." With some fruits, however, such as sour cherries, the trees may be inclined to break out into strong side-branches, and these should be removed.

Young, healthy budded stock should reach to a height of at least 4 ft. in the first year. The nurseryman now has to decide what form of tree he wishes to grow, and to head back his tree accordingly to 3 or 4 ft. Should any suckers spring out below the union, the earth must be carefully scraped away and such suckers cut off close to the stock.

It is always advisable to drive bamboo canes into the ground against each young tree, and carefully to tie the young trees to supports, so that they will not be blown over by the wind or broken off by careless workmen who may be working in the nursery. This will also ensure them being trained straight, making better trees in consequence.



78-84 ILLUSTRATIONS OF GRAFTING

78. Two scions inserted in cleft grafting **79.** Scion cut for cleft grafting **80.** Whip graft scion **81.** Whip graft in position **82.** Double whip graft scion **83.** Stock cut ready for a double whip graft **84.** Double whip graft scion in position

Cuttings and Layering. Practically all bush fruits, such as gooseberries and currants, are propagated by cuttings. Some, such as loganberries, are propagated by layering. There is no general rule as to the length of cuttings, but they usually bear from six to ten buds. They are taken in autumn from well-ripened new wood of the season's growth. They are then planted in rows on well-prepared soil, the rows being about a foot apart, and the cuttings about 2 in. apart in the rows. About a third of the cutting is placed in the soil, and care should be taken to give a slanting cut just below the bottom bud, as it is from the buds that the roots will form.

The method of layering loganberries is to bend the tips over and bury them in the soil without severing them from the parent plant. The tip strikes root; the new plants are severed when they have taken firm hold—that is, when they have begun to strike roots—and in the autumn are transplanted into the position that they are to occupy. If more convenient, they may be planted in a piece of ground where they may be kept for a year, and removed to their permanent place and wired in the second year. Blackberries are treated in the same manner.

Black currants and gooseberries are sometimes propagated by layering in the following way: outside shoots are bent down to the ground, and at one or more points covered over with soil about 3 in. deep. From each covered portion shoots will form, and a young plant is obtained by separation of these young plants so formed.

Raspberries throw out suckers or young canes direct from their roots. It has already been mentioned in the chapter on Pruning that raspberries bear on these young canes in the following year. Frequently, however, they make more canes than are needed for fruit-bearing—in other words, they produce more canes than the roots are able to supply with sufficient nourishment to produce fruit of economic value the following year, and also some in the centre between the rows where they are not required. These surplus canes can be dug up and transplanted, this being the means used for propagating raspberries.

Propagation of Strawberries. The propagation of the strawberry is quite different from that of any of the other fruits. The strawberry has the peculiar habit of throwing out a long, straight stem with joints at intervals. These stems lie on the ground and take root at the joints, and a young plant forms at these points. It was mentioned when dealing with the cultivation of the strawberry that these runners are cut off as soon as the fruit is picked, so as not to take the vitality from the parent plants, but if new plants are required for a new plantation some of these runners must be left. A single runner will produce as many as three or four young plants, but care should be taken to head them in, and to allow only one plant to form on each runner. This is done by cutting the runners off beyond the first plant. It is not advisable to attempt to propagate young plants unless the ground is somewhat moist, so that the young plants can obtain a foothold, because they have to strike root of their own accord without any soil being thrown over them as in the case of layering. These young plants should be strong enough for setting out in the September or October of the same year in which they spring from the parent plant. If, however, they are to be planted in a loose soil where the frost might cause them to be lifted out of the ground, it is advisable to leave transplanting them until the spring.

Creating New Varieties. Up to this point this chapter has given in brief outline the method of propagating fruits and the treatment they require in the nursery, which it is to be hoped will be of practical assistance to any who are ambitious enough to raise their own trees, bushes, and plants. We now pass on to deal with the discovery of new varieties, a much more scientific process, which

will be looked upon by the grower more as a hobby, because it takes a considerable amount of time and patience to meet with any success. Of the nurseryman's business, however, it forms a very important part. The enterprising nurseryman has always in his mind the possibility of adding to the varieties of fruit already in existence. With this end in view he tries to improve existing varieties which he possesses, to arrive at new varieties of special value, and also to raise entirely new fruits.

The account of this work may be divided into two headings—breeding and selection. The former consists in taking two different varieties or fruits and from them evolving a third, as, for instance, in the case of the loganberry, which is the result of a cross between the blackberry and the raspberry. It will readily be appreciated that a great many factors have to be considered in this important work, such as hereditary influences, environment, the chief characteristics of the two fruits that are being united in respect of such matters as texture, flavour, colour, sweetness, and season of ripening; likewise the stock of the parent trees.

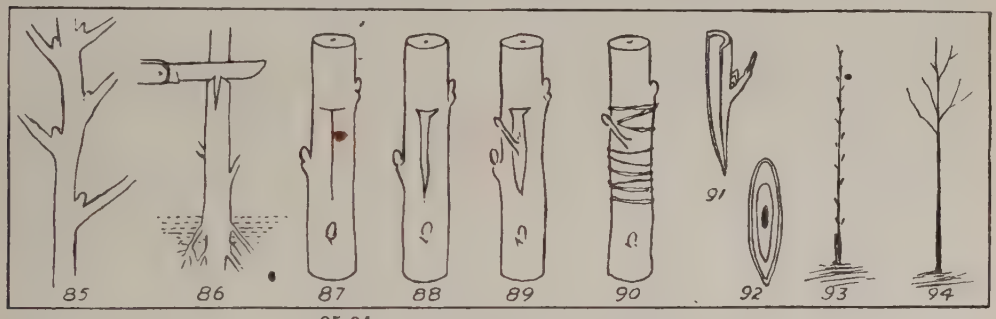
The actual process of breeding consists in extracting the pollen from the blossom of the one and depositing it upon the stigma of the other variety. This operation is termed pollination, and results in the blossom so treated being fertilised. This having been accomplished, Nature does her part.

It may be well to draw attention here to a fact that is not generally appreciated—namely, that, botanically speaking, the real fruit or seed is very often not what is eaten, but what is thrown away, as, for instance, in the case of the plum, it is not the pulp but the kernel inside the stone that is the true fruit—that is, it is that part which is the germ of new life. This is the case with the plum and also with the apple, while with the walnut and chestnut the outside is thrown away, and the part that is eaten is the seed from which the new life is to spring. This seed, whether it be the kernel of the plum or cherry, the pip of the apple, or the seed on the surface of the raspberry or strawberry, or the actual fruit of the chestnut, has to be sown, and the seedling raised gives us the new variety.

Selection. Selection is the practice of choosing the best, and is what might be termed a partner to breeding, the one being supplementary to the other. One of the greatest of plant-breeders of modern times is Luther Burbank, who has done most of his work in California, and has been termed the "Plant Wizard." He has not only improved domestic fruits, particularly plums, but has extended his work to flowers as well, and, what is far more important economically, has altered the character of the cactus plant.

The high economic value of this can hardly be recognised in this country. There are thousands of acres of dry, barren country in America on which nothing will grow with the exception of different forms of cactus, a plant that has caused thousands of pounds' worth of damage by lacerating the legs and sides of horses and cattle, not to mention the clothes of men who have had to travel across or live in the sandy desert plains. The cactus has now been so improved by breeding that a variety has been obtained with neither spines nor thorns, and edible for man and beast. This only shows what can be accomplished, and the endless field there is still lying untouched for the student of research.

Among other creations of this expert are the primus berry, which is a union of the raspberry and blackberry; the plumcot, a union of plum and apricot; a stoneless plum; a walnut with a shell so thin that the birds destroyed the nuts, necessitating a reversion of the process to secure the right thickness of shell; a walnut minus the tannin which gives to the thin, brown skin its unpleasant flavour; a chestnut-tree producing fruit in less than two years from the time of seed.



85-94. ILLUSTRATIONS OF BUDDING

85. A bud-stick **86.** Preparing the stock to receive the bud, showing the distance it should be inserted above the ground **87.** Stock cut ready for insertion of bud **88.** The bark laid back **89.** The bud inserted **90.** The bud tied in position **91.** Side view of bud ready to be inserted **92.** Back view, showing wood all cleaned out **93.** First year's growth of bud **94.** The tree pruned in the nursery after the first year.

The amateur will be disappointed if he enters upon the work of breeding lightly, for in some cases the best results are only to be obtained by employing the two methods of crossing and selection. Even then, in the case of plums, a number will have to be employed to combine the characteristics of the fruit that is ultimately desired.

When a bloom has been pollinated it is carefully covered over with muslin, to prevent any other agent, such as bees or insects, interfering. Later the fruit forms, and when thoroughly ripe the seeds or kernels are carefully preserved for sowing. Hundreds of thousands of these seeds must be sown. From these the young trees or plants will grow, and from those most promising scions are taken and grafted, usually on to old trees. Sometimes as many as a dozen varieties are grafted on to the same tree. Old trees are selected for this purpose because the scions will bear earlier than if grafted on young trees or left to bear by themselves. [See page 5064.]

As soon as they bear fruit a careful selection is made of those trees which have most nearly conformed to the ideal that the breeder has had in view. When it is remembered that perhaps only one in ten thousand of the seedlings will be any improvement on existing varieties, and that, as in the case

of plums, it will be four or five years before a fruit may be produced on this young seedling—and its merits cannot be judged until the fruit is produced—it will be readily appreciated that the work requires a great deal of care and patience.

Germination of Seeds. Everything depends upon the seeds and their proper germination. There are three fundamental requisites for the proper germination of seeds: (1) moisture, (2) temperature, (3) free oxygen.

Moisture must be considered the most important factor in the raising of seeds. Different seeds naturally require different amounts of water. This may be due either to the difference in the variety of the seed or because the seeds vary in their power of germination. Weak seeds require more attention and care in respect of moisture than strong, healthy seeds. A good plan is to cover the seeds with moss, which will keep the surface moist longer than if it were exposed direct to the air. It also aids in preventing the seeds from being washed out of the soil. It is always better to use a watering-can than a hose, in order that the watering may be gently done.

Even strong seeds should never be drenched, as that is likely to impair their vitality; the earth should simply be kept damp. The soil should be pressed firmly about the seeds, so as to prevent their drying too rapidly A good plan is to place the pots in which the seeds have been sown in a shady place, covering them with a piece of glass, having first laid a piece of stick across the pot on one side under the glass, thus allowing for ventilation to prevent the soil becoming sour.

Temperature and Germination. Although variations in temperature are not of so much consequence as variations in moisture, it is, nevertheless, very important that extremes should be avoided, and a comparatively uniform temperature should be aimed at. For this reason, as well as to keep them moist, it will be found advisable to keep them in at least partial shade.

It will be readily seen that if the seed pots or boxes are placed in the full glare of the sunshine in the daytime, there will be a great difference in the temperature in the cool of the evening.

A gentle bottom heat will be found to assist, particularly at night, in keeping an even temperature. It is difficult to lay down a fixed rule as regards the temperature required, as this varies according to the seed, but generally a temperature of about 60° F. will be found suitable for hardy fruits.

Free Oxygen and Light. The supply of oxygen usually regulates itself, but care must be taken that the seeds are not sown too deeply, and that the soil is porous, which aids ventilation. Badly ventilated soil will cause the seeds to rot.

Seeds will often germinate in full sunlight, provided care is taken to maintain the right degrees of moisture and temperature. It is well known, however, that some seeds will not germinate, or will only do so imperfectly, if subjected to a strong light. Unless one has made a very careful study as to the likes and dislikes of seeds in this connection, the safest plan is to keep them in at least partial shade. It is often stated that if seeds have once been allowed to become dry after sprouting they will become useless. This is not the case, however. Many seeds will re-germinate several times, and although, naturally, the best results are obtained by the seeds germinating only once, it is well to warn the amateur that his work is not entirely thrown away even if, through some oversight, the seeds have been allowed to become dry.

Seed Testing. It may save time and trouble if the seeds are tested before being actually sown. The simplest method of doing this is to soak hard seeds for a short time, then place them in a thick piece of flannel that has been soaked and laid in a shallow tray or dish, so that the flannel can be kept moist. Place the tray over a gentle heat, such as on the pipes of a cool greenhouse or in a frame. In the case of such seeds as raspberries and strawberries, it will be found that they will begin to sprout in about forty-eight hours. These sprouts are technically known as *chits*—in other words, the appearance of the chit is the first development of the germ of life. As soon as these chits begin to appear, the seeds can be sown, care being taken not to damage the chits.

Sowing. The seeds can be sown either in pots or in shallow seed-boxes, but, as a rule, the best results are obtained by sowing them in pots; particularly is this the case with the seeds of trees.

The soil must have perfect drainage, and this is more easily accomplished by using pots, as pieces of broken pots can be placed in the bottom, allowing the water to drain away. The soil used should consist of a liberal allowance of sharp sand and leaf mould. Good old garden loam, to which an equal quantity of sharp sand has been added, will make one of the best combinations. It is not a bad plan to place some coconut fibre in the soil, as it retains moisture and allows perfect drainage, thus helping to a considerable extent in keeping the soil aerated.

Care against Damping Off. One of the most common ailments of seedlings of this nature is that of *damping* or *rotting off*. The first indication is that the stem becomes brown close to the surface of the soil; it then rots and falls over. Strangely enough, it is a fungus that is the real cause of this; the top may remain alive and even fresh in appearance for several days afterwards. There is more than one fungus that may be answerable. Crowding and careless watering, causing a close and moist atmosphere, are principally responsible. For instance, when only sufficient water is given to keep the surface moist, while the soil underneath remains hard, the seedlings are liable to damp off.

As soon as the seedlings have grown to a height of three or four inches, it is well to transplant them into thumb pots, or even larger. A few months later they may be transplanted into a seed-bed in the open that has been carefully prepared. By the autumn they should have made a growth of from one to two feet, when they may be again transplanted into the nursery rows about 10 ft. apart. Here they may be left until they fruit.

It has already been mentioned that, to test the value of these young seedlings without waiting until they bear fruit themselves, the nurseryman will take buds or scions from them and work them on to trees of older growth, thus causing them to fruit earlier. In the meantime the seedling has been growing into a sturdy tree, so that, by the time that the bud or graft has demonstrated whether the fruit is of any commercial value, the seedling, if it is valuable, will be in a condition to furnish sufficient buds or scions for working a number of trees.

If, however, as is the case with 999 out of 1000, the new fruit is of no value, the work has not been entirely thrown away, as the nurseryman has a supply of stocks that have been carefully reared ready to be worked with a variety of fruit for which there is a demand, and they have afforded him an interesting study and possibly useful experience for his future work.

The Vegetable Basis of Artificial Silk. Chemical Principles of its Manufacture. Viscose Silk. Modern Uses.

ARTIFICIAL SILK

THE idea that silk might be artificially produced was perhaps first suggested to the mind of Réaumur when, in 1743, he conceived the possibility of forcing some of the fluid from the glands of the silkworm through minute orifices, or to the fisherman of some earlier date when he took the gummy fluid of the glands and drew it out for the purpose of producing a gut. In spite of these early observations, the production of silk from the natural fluid has been left to the silkworm's unaided efforts, and it was in quite other directions that chemists eventually succeeded in producing a commercial article in close imitation of the natural product.

Cellulose, a material entirely of vegetable origin, in one or other of its conditions, such as cotton or wood pulp, forms the basis of all artificial silk. This product is entirely different chemically from the material constituting the natural article. There are three independent methods employed in making artificial silk. They are as follows: (1) nitro silk, (2) cuprammonium silk, (3) viscose silk.

Nitro Silk. The discovery that gun-cotton could be got into the condition of a tacky fluid (collodion) by dissolving it in a mixture of ether and alcohol led Andermars, in 1855, to take out a patent for drawing off filaments from this solution. This may be said to be the beginning of the production of artificial silk by the nitro process. This silk was very inflammable. Weston, in 1882, patented the de-nitration of nitro-cellulose by treating the inflammable silk with such reagents as ammonium sulphide, which resulted in a product which is no more inflammable than ordinary cotton, although still containing a small residue of nitrogen. In 1884 Count de Chardonnet succeeded in forcing collodion through small apertures or orifices, and Lehner made certain important advances in its production, particularly in regard to the viscosity and concentration of the spinning solution. The former eventually established large works at Besançon and the latter at Frankfort-on-the-Main. The process as at present conducted is still more generally known as the Lehner-Chardonnet process. Filaments are forced through capillary glass tubes into the air, into an enclosed chamber from which the vapour of ether and alcohol is, as far as possible, recovered. The filament immediately sets to a thread, and is wound on to holders, and rendered non-inflammable by treatment with de-nitrating agents, after which it goes through other operations, when it finally emerges as the finished skein.

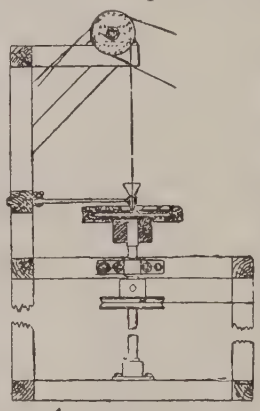
Cuprammonium Silk. The discovery which eventually led to the introduction of the cuprammonium process is generally attributed to Schweitzer, who in 1859 discovered that cellulose is soluble in a basic copper compound, or in copper hydroxide in the presence of ammonia; but the real discovery may be said to date from Mercer's discovery, of an earlier date, that copper nitrate spread on a piece of cotton fabric, if moistened with caustic soda and subsequently with ammonia, produces a reagent which is capable of dissolving the cellulose. Cotton may be dissolved by adding slowly to a little copper sulphate solution a solution of caustic soda until the whole of the copper is *just* precipitated, washing the precipitate on a filter paper, which precipitate, if moistened with strong ammonia, will be seen to change to a deep blue colour and to immediately dissolve the cellulose of the filter paper. This simple experiment is easily tried by the student.

How Artificial Silk is Made. The general modus operandi is to take cotton which has been previously cleansed from impurities by boiling in soda and bleaching, and to add to it a certain proportion of precipitated basic copper salts produced as above described. This mass, after thorough incorporation, is pressed to remove the excess of moisture, in which condition it is known as "blue-cake." It is then put into an enclosed chamber, together with a certain amount of ammonia, water, and other ingredients, and by the aid of mechanical stirring it is reduced to the condition of a viscous blue fluid. This liquid is pumped under pressure to the "pinnerettes." These consist of perforated discs attached to nozzles made to discharge into a coagulating bath. Through the minute holes in the nozzles the threads emerge into the chemical liquid. This liquid, according to the older method, and still largely practised, is sulphuric acid. This immediately converts the lipuid into a number of solid-made microscopic threads of regenerated cellulose, with the simultaneous production of ammonium sulphate and copper sulphate in the coagulating baths. The thread passes on to holders, whence it is washed, bleached, dried, spun, skeined, and finished. The coagulating bath has to be carefully maintained at constant temperature and constant composition. Each nozzle is provided with a sufficient number of holes, usually about sixteen, to form the yarn. The speed at which the thread passes through the coagulating bath is about forty yards a minute. By varying the consistency of the liquid, the size of the orifices, as well as the number of holes and the speed, yarns of different weights, or "counts," can be produced. For preparing the different "counts" (*i.e.*, denier) the number of threads is commonly varied.

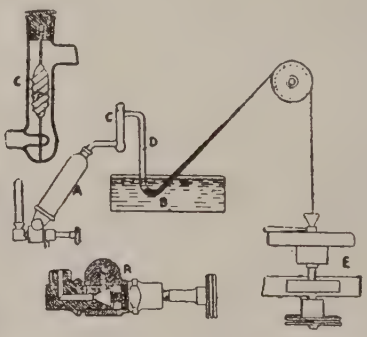
Some Recent Improvements in Manufacture. In 1890 Despessis took out a patent for the manufacture of artificial silk by the cuprammonium process, and this was followed by a large number of patents by Bronnert, Fremmery, Pauly, Urban, Linkmeyer, Friedrich, Dreaper, Tompkins, and others. The artificial silk was originally produced by coagulating in strong acids at low temperatures. It was subsequently discovered that the silk could be produced to better advantage in weaker acid and at a more moderate temperature. Great improvements have resulted in the manufacture of artificial silk by the cuprammonium process in consequence of the introduction of an alkaline precipitating bath consisting of caustic soda with or without the addition

of other salts. In some cases a stronger and more elastic thread results, and the difficulties resulting from the use of a strong acid are avoided. Side by side with these rival processes the cuprammonium process has made great advances during the last few years. As the chemicals used are expensive in comparison with the viscose process about to be described, the completeness of their recovery and their use over again is an important matter. Both the ammonia and the copper are recovered and used again, whereas with the viscose process the resulting by-products have to be disposed of, as they are not capable of recovery. By the cuprammonium process, not only is artificial silk produced, but also a single-thread substance in imitation of horsehair which has formed an important article of commerce in Germany for the manufacture of crinoline for ladies' hats. This product fetches sometimes a higher price than artificial silk. There are difficulties in the way of producing this class of article by the viscose or other process, the cuprammonium process being pre-eminently suited to the production of monofils from fine hairs to thick guts.

Viscose Silk. Mercer's classical discovery that strong caustic soda had a peculiar action upon cotton, causing it to swell up, bringing about the process of mercerisation, is the basis of what is now a very large industry in the shape of mercerised cotton goods. No commercial use seems to have been made of Mercer's discovery for at least twenty years. In 1892 Cross, Bevan, and Beadle discovered that mercerised cotton is capable of being converted into a soluble substance by the addition of carbon bisulphide. Thus, to cotton pulp is added a strong caustic soda solution. The mass swells up to the condition of breadcrumbs. To this is added carbon bisulphide in a closed vessel. The product gradually changes to a yellow buttery mass which, on the addition of water and stirring, dissolves to a clear, treacly liquid. This product is known as *viscose*. For the manufacture of viscose silk this has to be very carefully prepared, filtered, and squirted through fine orifices into a coagulating bath, from which it emerges in the form of a filament, afterwards undergoing various mechanical and chemical processes, after which it forms the viscose silk of commerce. The chief raw material in the manufacture of nitro and cuprammonium silk is cotton, but for viscose silk wood pulp is almost exclusively used.



1. SPINNING BOX



2. VISCOSE SPINNING PLANT

In 1894 Stearn projected a solution of viscose through a small orifice into a precipitating or setting solution, which converted the liquid into a solid filament. Viscose has the peculiar property of being solidified by such substances as brine, sulphate of ammonia, etc., so that if a thin thread of liquid be projected into a bath of such solution it becomes a solid thread.

Improvements were made by Topham for filtering the solution by passing it through various filtering media to deprive it of every particle of dirt or fibre, the plant being so arranged that every particle of air is eliminated [2]. This is absolutely necessary, or the nozzles would otherwise get blocked and the threads broken. The manner of manipulation now is that a number of threads, perhaps twelve at a time, are drawn or forced through a perforated plate, immersed in the setting solution [B 2], then over a pulley, and then are twisted together by an ingenious spinning contrivance [E 2 and 1], where centrifugal force is taken advantage of in giving the filaments a pull and a twist; the thread is laid as an annular mass, which is periodically removed from the box.

In the production of artificial silk absolute control in every respect was found to be essential. Thus, the rate of flow had to be automatically regulated. This was formerly done by a glass valve float fitting a tube [C 2], and floating in the solution and covered on its surface with veins or spiral grooves, through which the solution finds its way. This flow causes the valve to rotate, and, by the position of the float, the supply is automatically controlled, and delivered in a regular stream from the pump to the squirting nozzles. This valve can be set to alter its delivery according to requirements.

Important improvements rapidly followed in all stages, including the preparation of the viscose, dissolving, agitating, stirring, spinning, precipitating, and in the subsequent treatment of steaming, washing, purifying, bleaching, drying, etc.

Care Required in Spinning. It will readily be realised that the diameter of filament is dependent upon the pull or "draft" from the squirting nozzle in relation to the amount of solution passing through the fine orifices, and that this has more to do with the fineness of the thread than the actual diameter of the holes through which it passes. The lustre, feel, elasticity, and physical qualities generally, are affected and controlled by such considerations. But apart from these, and the chemical and physical qualities of the liquid viscose, the processes that follow the first formation of the thread produce profound modifications, such as stretching and drying under tension which are important in their influences.

Viscose Filaments. The filaments are not necessarily circular; in fact, magnified sections show them to be angular, due, no doubt, to their contact one with another while still in a mouldable condition. Exactly the same influences are at work in a state of Nature as with flax and esparto fibres. When a bundle of fibres are pressed evenly together, either by reason of their internal growth and expansion or pressure upon them exerted laterally, the tendency is to the formation of tubes, hexagonal in section. Stearn confined his attention to the problem of rendering viscose a homogeneous product, discovering a suitable precipitant that would enable the spinning to be done at a high speed, and

investigating the physical changes that occurred during the ripening, and to devising mechanical appliances for producing a uniform product.

In the course of development it became manifest that careful preparation of the solution was of paramount importance. This had to be attended to at every stage; and there is as much science and skill needed to accomplish this as is necessary in the brewing industry—perhaps even more so.

Ageing. We have already stated that the viscose solution is undergoing molecular changes from its very inception to the time of its coagulation. For spinning, the solution has to undergo a process of "ageing," and further chemical treatment, and at the right stage it is spun so that the filament becomes coagulated or solidified *while still in a soluble condition*, and is subsequently rendered insoluble. This important advance we owe to Stearn. Viscose silk [3] is now prepared in large quantities. It possesses the most beautiful lustre and excellent qualities for spinning and weaving.

The production at first was slow, but there are now a number of factories producing the artificial product, and artificial silk, by one or other of the well-known processes, is likely to become one of the most important industries of the future. A minute examination of the history of these several processes is perhaps one of the most valuable object lessons to the young aspiring chemist.

A monograph on "Cellulose," by Cross, Bevan, and Beadle (Longmans, 1s.), and later publications, might with advantage be consulted by students who desire a closer acquaintance with the chemistry of the subject.

Difficulties in Manufacture. The difficulties in the successful manufacture of artificial silk are enormous, and it is hard to say which process offers the greater difficulties. Many millions sterling have been spent in different countries in arriving at the best methods and in achieving commercial success. Between laboratory experiments and proper factory routine there is a great and almost insurmountable gulf which has taken the now successful concerns many years of indomitable industry and hard labour to bridge over.

3. SKEIN OF ARTIFICIAL SILK

Among the numerous difficulties may be mentioned the proper choice and preparation of the raw material, which means all the difference between success and failure. Cotton is perhaps the chief raw material at present used, as it serves for both the nitro and cuprammonium processes, but, unless the right kind of cotton and cotton of the right condition be chosen, the final result will be useless. The choice of the material is a matter of extreme difficulty. Wood pulp, the alternate source of supply, also presents similar difficulties. At every stage of the process difficulties arise, making themselves evident in the spinning bath or when the final product comes to be tested. It is necessary to produce skeins of uniform thickness, gloss, colour, strength, and elasticity, and possessing these qualities combined in such a manner as to be of service for the different purposes to which the material is to be put. The dyeing qualities also have to be studied. The dyeing, of course, is almost universally done by the dyers, and not by the manufacturer of the artificial silk, who only carries the process as far as the skeins or spools, which are left either as unbleached or bleached yarns to suit the purchaser's requirements.

It will be seen from the foregoing description that artificial silk, by whatever process it is produced, is forced in the form of a viscous fluid through minute holes or orifices either into some suitable fluid which sets it to a solid thread, as in the case of the cuprammonium and viscose process, or into the air, where the solvent leaves as a vapour, as in the case of collodion or nitro silk. These minute threads have to be produced continually day and night from the beginning to the end of the week, if possible without breaking. There are cases in which each attendant has to look after as many as 80 spinnerettes, which is equivalent to the care of more than 1000 individual microscopic threads, produced at the rate of 40 yards per minute. If no break occurs, there is comparatively little to do, but if the slightest thing goes wrong with the solution, resulting in the breaking of a tiny thread, the operator must put it right at once. Where every care is taken over the preparation of the solution by the observation of minute details, the work goes on with mathematical precision, but a slight error in the preparation of the solution may bring the whole operation to a standstill.

Physical Properties. Artificial silk can be made softer and more brilliant than natural silk, but it possesses less strength, and its strength is impaired by wetting; consequently greater care has to be exercised in the washing. On drying, artificial silk recovers its original strength. The coarseness or fineness of the yarn is measured in "deniers." One denier is equal to the weight of half a decigramme on a skein of 450 metres. The following table gives the relationship between denier and cotton counts. The basis of counts is the same for raw, thrown, and artificial silk.

80	denier	artificial	silk	= 64·50	cotton	counts
100	,,	,,	,,	= 53·16	,,	,,
120	,,	,,	,,	= 44·30	,,	,,
130	,,	,,	,,	= 40·75	,,	,,
140	,,	,,	,,	= 37·80	,,	,,
150	,,	,,	,,	= 35·44	,,	,,
160	,,	,,	,,	= 33·08	,,	,,
170	,,	,,	,,	= 31·25	,,	,,
180	,,	,,	,,	= 29·53	,,	,,
190	,,	,,	,,	= 27·50	,,	,,
200	,,	,,	,,	= 26·58	,,	,,
250	,,	,,	,,	= 21·26	,,	,,

Microscopic Fineness of Threads. An ordinary double skein of artificial silk weighs, say, ½ oz., and has a length of 1000 yards, but as each yarn thread such as the weavers employ consists of, say, 15 individual filaments, the ½ oz. skein will contain a length of 15,000 yards, and the 1 oz. of 30,000 yards, of the microscopic filaments. The pound contains, perhaps, if fine, 400 miles of these

tiny threads. At the present price of artificial silk one can obtain 400 miles for 5s. or 6s.; enough for £15 to £20 to lap once round the world. Artificial silk is perhaps one-third to one-fourth the price of natural silk.

The holes through which the liquid is forced are about $\frac{1}{1000}$ of an inch in diameter, and, as these tiny threads undergo further contraction, they are not more than $\frac{1}{10000}$ of an inch in diameter when finished. Even then they are not so fine as real silk, but are fine enough for commercial purposes, and if finer would not be so useful.

By the Tiele process very fine counts are producible, the individual filaments having a fineness of as little as 1 denier. As the yarns commonly used have about 15 individual threads and go about 150 denier, the ordinary unit filament has about 10 denier. The denier of bave of natural silk is, say, 2 to 3. It will thus be seen that, although the artificial silk normally produced and in demand is not so fine as the natural product, it is quite possible to produce it fine should the market require it, but the finely drawn-out artificial silks appear to suffer in gloss.

Uses of Artificial Silk. A few years ago it was estimated that three-fifths of the production of artificial silk yarns was used in the manufacture of such goods as laces, trimmings, embroideries, ribbons, millinery, and upholstery goods. Some of the silk-weavers, foreseeing the profit that could be made if artificial silk could be used in the manufacture of piece goods, continued their trials quietly, and finally compelled the artificial silk-yarn manufacturers, by their repeated requests, to modify their processes so as to produce thinner grades with a silkier feel. Much is now woven into piece goods and dyed in the piece; the result is most gratifying, and the goods are sold in large quantities.

Artificial silk yarns have met with great success in the manufacture of fabrics in which the warp is of a cheaper material than natural silk and the weft of artificial silk, and also in the manufacture of goods in which is used artificial silk spun jointly with other textiles. In the near future the sale of such fabrics is likely to open up a large and increasing field.

Artificial silk, which has been greatly improved and cheapened both by the cuprammonium and viscose processes, has reached such a state of perfection both in regard to methods employed and quality of material produced that, instead of limiting its use almost exclusively to mixed cloths, upholstery and millinery goods, braids, laces, etc., as heretofore, it is now being gradually employed in making all kinds of fabrics composed wholly of artificial yarns, as is done with natural silk, the production increasing more and more every year.

Substitutes for thrown and spun silks are being increasingly used in the manufacture of neckties, ribbons, tapes, braids, and other small wares. Artificial silk is also used in the manufacture of lace embroideries, etc.; its uses are extending, and for some purposes it is preferred to natural silk.

4. A VIEW SHOWING THE WINDING AND SKEINING OF ARTIFICIAL SILK FROM WOOD PULP IN A LARGE FACTORY ON THE CONTINENT

The following table is intended to give some rough idea of the world's production of artificial silk. This is only an estimate; it is impossible to arrive at anything like the exact figures, as there are no returns available.

—	Total lb.	Nitro-Cellulose	Cupram-monia	Viscose
1904..	3,100,000	—	—	—
1905..	4,400,000	—	—	—
1906..	5,100,000	—	—	—
1907..	6,600,000	—	—	—
1908..	8,800,000	4,400,000	3,300,000	1,100,000
1909..	12,100,000	—	—	—
1910..	12,800,000	4,800,000	4,800,000	2,400,000
1911..	12,800,000	—	—	—
1912..	13,200,000	3,300,000	5,500,000	4,400,000

The total production of the world is now variously estimated at somewhere between 12,000,000 to 20,000,000 lb. per annum.

CLAYTON BEADLE AND H. P. STEVENS

A Dictionary of Special Terms and Phrases used in Chemistry appears at the end of the Self-Educator

Time-tables. Passenger Train Staffs. The Passenger Train. Comfort and Luxury. Train Lighting. Salvage Appliances. Rail Motor-cars. Tickets and Fares.

PASSENGER TRAFFIC

THE superintendent of the line, or general superintendent in the case of those companies which have divided the operating from the commercial side, is responsible for the preparation of the time-tables, both public and working. A public time-table, which refers only to the working of the passenger traffic, is issued twice or thrice a year—the summer train service, for the months of July, August, and September, and the winter train service, which remains in force from October 1 to June 30 following, though a few companies issue a third time-table for the months of May and June. It will be easily understood that there is a greater volume of passenger traffic in summer, and a greater volume of goods and mineral traffic in winter.

Time-table Work. A working time-table, which forms the real key to the working of the traffic, deals not only with the arrival and departure times of passenger trains at stations, but also fixes, for the guidance of the staff, their passing times at junctions and stations where they do not stop. In addition, it gives the working of all goods, mineral, special, and empty trains and light engines; in short, every movement of traffic which takes place outside station limits. Can it, therefore, be wondered that a working time-table should be a ponderous volume, which, as a rule, has to be issued in parts for the different sections of the system? The "heavy" lines publish a fresh working time-table each month; and every week, or sometimes every day, supplement it with addenda relating to the altered working necessitated by special trains, duplication of ordinary trains, and the exigencies of the engineering department.

Some companies make use of diagrams, which are prepared for each section of the line, showing how the engine working is arranged, the time and speed of running, and the intersection of the trains where goods and slow passenger trains have to shunt for the express trains to pass them. The London and North-Western diagrams are drawn to scale, with perpendicular lines dividing the day of twenty-four hours into periods of hours, half hours, quarters of hours, and of five minutes; and with horizontal lines dividing the railway into sections of miles-chains, while slanting lines are inked in to represent the traffic timed to run over the line. Thus, the diagram offers a visible picture of the state of the line, whether it is occupied or otherwise, between any two points at any minute of the day; and with this type of diagram any abnormal speed of a train, wait at stations, length of day for the men, or idle time of engines can readily be detected.

Time-table Conferences. Before a time-table is materially revised, time-table conferences—usually summer and winter—are held, which meetings are attended by all the divisional superintendents, together with representatives of the locomotive department, and presided over by the superintendent of the line. Prior to the holding of a conference, suggestions for new trains or altered workings have reached the office from all parts of the system, and such suggestions which are invited must be accompanied by particulars, specifying reasons, likely advantages, and the total increase or decrease of engine and train mileage which each change would involve. The conference thoroughly threshes out these proposals, approving of some and rejecting others. Approved suggestions go to the general manager and traffic committee for ratification, after which the time-bill clerks attached to each divisional superintendent meet and work up the details, filling in the junctions and passing times.

Rectifying Slack Train Working. It would be manifestly a herculean task to arrange the working of trains on a great railway from the very beginning without some previous knowledge of requirements and possibilities, but as traffic develops gradually the work is very much simplified. Of course, the superintendent of the line has to arrange his time-table in unison with that of a friendly foreign company, and at the same time to keep a watchful eye on the doings of competing lines, so as to be prepared to counter accelerations or new trains which might steal traffic from his own company. In arranging for a new train, the first difficulty is to get the others out of the way, and having put in the trunk, so to speak, the second difficulty is to feed and run off it by means of local trains, connections at junctions, and rail and road motor-cars. "Train-runners," or travelling inspectors, are attached to the office of the superintendent of the line. If from the reports that come into the office, either officially or privately, there be reason to suspect any slackness in the working of a train—if a train consistently loses time, or a locomotive be thought not to be doing proper work—a runner is despatched to travel by that train in order to locate and report upon the mischief. Similarly, goods-train runners are sent out to various places to see how the working of the goods traffic can be improved.

Porters, Ticket-collectors, and Conductors. The various grades of the staff associated with the working of the passenger traffic must now be explained.

Porters are divided into platform porters, earning 15s. to 19s. per week; luggage-labelling porters, with 18s. to 23s. per week; luggage-stowing porters, cloak-room porters, and parcel-post porters, earning 16s. to 18s. per week, the peculiar duties of each being explained by their designation, with the exception, perhaps, of the luggage-stowing class. These latter, who are only found at the great terminal stations, are responsible for stowing passengers' luggage in the vans where it can be most easily handled during the journey. For example, the guard must not find his Exeter luggage buried beneath the Plymouth. Platform porters meeting trains are enjoined to attend to the compartments opposite to them, irrespective of class. The duties of ticket inspectors (35s. to 47s. per week) and ticket collectors (28s. to 35s. per week) are to examine and collect tickets, together with excess fares. The best men are selected to become travelling inspectors in corridor trains, where they are generally expected to act as con-

ductors or attendants as well, while in some cases they fulfil the duties of junior guards, but without the pay of that rank.

The increase of corridor trains is, in fact, bringing into existence a distinct conductor class, which must not be confused with that of dining or sleeping car attendants, and which is not necessarily recruited from the ticket collectors. Thus, the Great Northern Railway furnishes "lavatory attendants" on its "crack" trains, and the Great Western Railway inaugurated the practice of having male and female attendants to accompany its Cornish expresses. The Great Western male attendants do more than attend to the lavatories; their services are available for valeting a passenger, while the female attendants, who wear a kind of nurse's unform, will chaperone ladies travelling unescorted, and look after children while their guardians are at meals in the restaurant-car.

Shunters. Very few shunters are employed in the passenger traffic department, as almost all shunting of passenger vehicles is performed by engines, while the movements demanded of this kind of rolling stock are comparatively few and far between. In the working of the goods traffic, however, a large army of shunters is required, and the duties of the men are far harder and call for greater intelligence than in the passenger service. Passenger shunters are practically confined to the sheds where the trains are marshalled. The grades of shunters are as follow: superior foreman shunter, foreman shunter (earning 25s. to 38s. per week), shunter, and assistant shunter (wages 18s. to 32s. per week).

Guards. Just as the passenger train takes precedence of the goods, so the passenger guard [53], as a rule, takes precedence of the goods guard, although not a few among the latter are the better off in respect of pay. A guard is responsible for the proper equipment of his train before starting, the safety and comfort of the passengers during the journey, and must, after the foregoing, give his next attention to the luggage, parcels, despatches, and other packets entrusted to him. Mail-bags are usually accompanied by postal officials; when they are not, the guard is responsible for their safety. It is not generally known that railway companies send their own voluminous correspondence, as far as is practicable, by rail direct, instead of through the post; hence the guards of the night expresses are also called upon to act as sorters to a certain extent.

Duties of Guards. On joining his train, every passenger guard must have with him his watch, whistle, and carriage-key, and take in his van a red and a green flag, not less than twelve detonators, and a hand signal lamp, which must be lighted when passing through long tunnels, and after sunset and in foggy weather. In the event of a breakdown the rear guard must protect the train, by going back for a prescribed distance and placing detonators on the line.

During the journey a guard has a good deal of clerical work to perform. Every parcel is accompanied by a way-bill, which has to be checked, and any irregularity notified. Then, a guard has to keep a journal or "log" of his train, which furnishes a most important record as to proper time being kept, and illustrates a variety of other features concerned with the smooth and economical working of the traffic. In his journal he records the actual time of arrival at and departure from every stopping station; the number of minutes late away from a station; the time lost, and whether due to station, engine, or signals; if signals, whether they were ordinary or engineering signal checks; the number of carriages, carriage-trucks, horse-boxes, and vans taken on and put off; the number of wheels on leaving station where load is altered; remarks as to detentions at stations and in running; general remarks, occurrences to trains, causes of delay, and suggestions for improvement of working; state of weather during journey, if wet, wind, frost, fog, or snow, and between what points; particulars as to whether train was full or empty in each class of compartment; the numbers of the engines employed, and the names of the enginemen and the names of the junior guards. The journal of every through train is sent to the superintendent of the line or running superintendent, and that of every local train to the proper divisional superintendent. The journals of the previous day are carefully scrutinised every morning; and if the examiner find any delay or occurrence which is not, in his opinion, properly accounted for, he wires the divisional superintendent in whose division it happened for a full explanation.

Salvage Appliances. After the Hawes Junction collision, in 1910, the Board of Trade recommended that fire extincteurs and various tools for rescue purposes should be carried on express trains. The companies hastened to supply these, and they are usually stored in cupboards in the guards' vans. When an accident occurs, the guards are responsible for opening the cupboards and handing the tools and other appliances to the train attendants and passengers. The Aisgill disaster, in 1913, pointed to the need of adding a box of surgical dressings to the appliances, and supplying more powerful tools for extricating passengers from wreckage. It also led to the Board of Trade recommending the same, and that the companies should instruct their guards and attendants more thoroughly in general principles of salvage work, and impress upon them that, in an accident of this description, it is of first importance to arrange for someone to watch for any outbreak of fire, and make preparations to fight it.

Grades of Guards. The grades of passenger guards are according to the different ratings of trains, which classification usually comprises: (1) through or express trains; (2) main-line stopping trains; (3) local trains. Some companies, or combination of companies, like those working a through Anglo-Scottish service, have a superior grade of guards, who accompany a train, say, from London to Aberdeen. These men wear a more elaborate uniform, and are dignified with the title of "conductor."

Wages and Promotion of Guards. The wages of passenger guards are from 23s. to 40s. per week; relief guards are paid 27s., pilot guards 25s., and porter guards 20s. It may be noted that a guard of a long-distance through train is seldom as well off as his wages of 40s. per week would imply, inasmuch as some companies give these men no lodging allowance, and they have therefore to maintain what are practically two homes, one at each end of the line. Some companies, again, provide barracks for guards making long journeys. As a rule, a man is promoted straight to guard, and appointed to the charge of one of the least important local trains. But one or two companies have an intermediate grade in the shape of passenger brakesmen, who assist in local workings as required. During the holiday season, the services

of goods guards, with whom it is the slack time of the year, are requisitioned to staff excursion trains. Two or more guards are carried only on trains which are heavily loaded with passengers, luggage, or parcels. The length or intrinsic importance of the train does not affect the question. The business man's city train invariably requires two guards, as one guard would not suffice to ensure smart working. Then, a train may start with only one guard, and pick up another farther down the line. Where two guards are carried, with some companies it is a rule that the head guard occupies the rear van, and the junior guard the front, while with others it is just the opposite, as it is considered that the head guard should be in the van next to the engine. Some companies require all parcels to be placed in the front van, and luggage and mails in the rear; others, again, order it all to be equally divided, as far as possible, throughout the train.

Slip Coaches. "Slip" guards have to undergo special training, and their duties, which call for the exercise of considerable judgment and discretion, can be explained only by describing the practice of *slipping* itself—that is, attaching a carriage to an express train in such a manner that it can be detached at a station while the rest of the train, termed the "main train," passes on without stopping. The advantages of the system are obvious. It allows of "express" journeys to many places which are not of sufficient importance to warrant the stopping of an express train. "Slip" coaches are nearly as old as the railways themselves. One of the earliest lines—namely, the London and Greenwich—was worked in the "down" direction solely on the "slip" coach principle. The main train did not stop till it reached the terminus; meantime a carriage was "slipped" at every intermediate station.

So long as trains were controlled by hand brakes in the guard's van and on the engine, the slipping of coaches required no more complex apparatus than a special form of coupling. However, the adoption of automatic continuous brakes has compelled the use of additional apparatus, whereby the brake hose can be disconnected without impairing the efficiency of the brake power in either the main train or "slip" portion. There are two kinds of automatic continuous brake in use by British railways—the vacuum and the air. Consequently the method of slipping with each differs somewhat. However, we will describe the process as carried out by a railway employing the vacuum brake. A *slip coach* is a composite carriage, with a slip compartment at each end, equipped with a hand brake, a lever operating the slip coupling, a brake indicator, a brake setter valve, and vacuum gauges. The main train is coupled to the "slip" coach by means of a special coupling hook [64], the jaws of which are released by pulling over the aforesaid lever. Underneath the latter is a diaphragm which, while a vacuum exists throughout the train, locks the lever. At the last stopping-place, a slip coupling cock is attached to the brake hose at the point of severance, and its handle is turned to the left, in which position the passage is open for the maintenance of a vacuum throughout the train. The switch of the vacuum brake indicator, contained in a little bracket table, is also turned to the left, so that the indicator displays a shutter inscribed in red letters, "Wrong to slip."

Slipping a Coach. From one to three miles away from the slipping point, the "slip" guard leans out of his end window [66] and pulls a cord which turns the handle of the "slip" coupling cock parallel with the hose. He next turns the switch of the vacuum indicator in the same direction. The result of these two operations is that the "slip" portion now forms a separate and self-contained unit. The vacuum brake, as controlled from the engine, ends with the tail coach of the main train, while the slip portion has retained a residuum. Still the slip coupling cannot be released, as there is a third vacuum holding down the diaphragm. Just before reaching the slipping point, which must be judged to a nicety, the guard lifts the handle of the brake setter valve; a sharp hiss, and the vacuum locking the diaphragm is destroyed, while, at the same time, the indicator displays a fresh shutter, inscribed in white letters, "Right to slip." Then, at the right place, the slip guard pulls over the lever, whereupon the jaws of the coupling hook open, the brake hose parts at the joints, and the train runs in two portions, as shown in 52.

With the London and North-Western Railway all the operations of "slipping" are accomplished more simply by means of a pneumatic apparatus. The rear guard of the main train and the "slip" guard exchange signals, with green flags or lamps, to indicate that the "slip" has been satisfactorily effected. The momentum of the "slip" portion is checked with the hand brake, for the power stored in the power brake is reserved for use in case of emergency. The Board of Trade regulations prohibit "slipping" in a fog, and the companies' rules enjoin the "slip" guard to see that the "distant" signal is "off" before he slips. At night a "slip" portion carries a head-light and also special tail-lamps to distinguish it from those of the main train.

Responsibilities of the Stationmaster. Stationmasters are answerable for the security and protection of the office and buildings and of the company's property there. They are responsible for the general working of the station, the control of the staff, and the economical use of stores. They must take care that waiting-rooms, offices, platforms, and name-plates are kept neat and clean, and must also see that copies of the company's by-laws, Carriers Act, list of fares, statutory and other notices are kept properly exhibited. At important stations the stationmaster attends only to the passenger work, and is accountable to the superintendent of the line, while his confrère the goods agent is responsible for the goods working, and comes under the control of the goods manager. There are stations of such little importance that the stationmaster is the only servant employed thereon, and acts as porter, parcel clerk, and signalman as well; nevertheless, he ranks as a third-class stationmaster, and is uniformed accordingly.

Second and third class stationmasters are weekly paid servants (wages 25s. to 47s.), who have risen from lad porters, while first-class stationmasters receive salaries, and, as a rule, are selected from the clerical staff. Lastly, there is a specially high grade of stationmasters in command of the great terminal stations. Some companies make all their stationmasters except the last-named (who are expected to wear frock-coats and top-hats) wear complete uniform. Others, however, confine the wearing of complete uniform to the second and third class grades, first-class men being allowed to don mufti, though they must wear an official cap, while they garb their stationmasters-in-chief in an elaborate uniform. The stationmaster of a London terminus is a very important official, and when a man has risen to this height the chances of his

48. PLATFORM REFRESHMENT STALL AT A STATION ON THE MIDLAND RAILWAY

49. RAIL MOTOR COACH ON THE LONDON AND NORTH-WESTERN RAILWAY

50. STEAM RAIL CAR, WITH COCHRAN BOILER, ON G.N. OF SCOTLAND RAILWAY

51. PETROL-ELECTRIC AUTOCAR ON THE NORTH-EASTERN RAILWAY

52. EXPRESS TRAIN SLIPPING A COACH TO SAVE A STOP

53. GUARD OF L. AND N.W.R. EXPRESS

54. SLEEPING-SALOON STATE CABIN ON THE L. AND N.W. RAILWAY

55. A PULLMAN CAR

56. G.N.R. PETROL RAIL MOTOR CAR

57. RAIL MOTOR CAR WITH TRAILER ATTACHED ON THE GREAT WESTERN RAILWAY

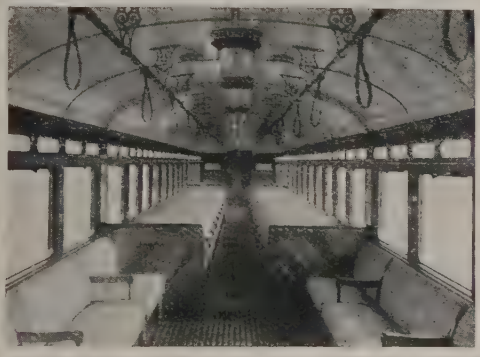
GROWTH OF COMFORT ON THE RAILWAY

58. MAIN LINE CORRIDOR VESTIBULED DINING-CAR EXPRESS ON L. AND N.W. RAILWAY

59. APPARATUS FOR THE MECHANICAL WASHING OF COACHES

60. BLANKET, PILLOW, AND RUG STORE, L. AND N.W. RAILWAY

61. RUG AND PILLOW BARROW ON L. AND N.W. RAILWAY



62. INTERIOR OF A G.W.R. RAIL MOTOR CAR

63. N.E.R. PASSENGER MOTOR OMNIBUS

64. SPECIAL COUPLING HOOK FOR SLIP COACHES

65. PASSENGER ROAD OBSERVATION MOTOR-'BUS

66. SLIP COACH, SHOWING END WINDOW

67. COMPOSITE DINING-CAR ON THE GREAT WESTERN RAILWAY

ultimately attaining one of the plums of the railway service are pretty well assured.

Traffic Inspectors. Broadly speaking, inspectors are divided into chief inspector, divisional inspector, inspector or sub-inspector, assistant or platform inspector.

The chief inspector is the divisional superintendent's right-hand man, for safe traffic-working first, and for appointment and preferment of the staff secondly. With some companies he ranks as head of the weekly paid staff; arranges all the duties of that staff, together with their annual leave, and when the engineering department requires occupation of the line the arrangements are made through him. In any case, the chief inspector is constantly about the line, making suggestions and conveying instructions with the authority of the superintendent of the line or general superintendent behind him. He, too, is among the officials who accompany Royal trains. The next grade of inspector may be either divisional inspector, responsible to the divisional superintendent, or sub-inspector, in charge of a district, earning from 35s. to 47s. per week, and responsible for all detail work under the chief inspector. The assistant or platform inspector (wages 32s. to 50s. per week) is the stationmaster's deputy at every big station. Under the stationmaster he is responsible for the timekeeping, good order, and cleanliness of the station staff, for the prompt despatch of trains, and for the loading and unloading of luggage and parcels.

Train Formation. The stationmasters are responsible for the proper make-up of passenger trains, although they have to delegate their responsibility. Through passenger trains are marshalled in the carriage sidings or sheds attached to the starting place of such trains. A *programme* is prepared showing the fixed formation of every train—that is, the number of coaches, the class of coaches, the number of compartments, the lavatory accommodation, dining or sleeping cars, Post Office or parcels vans, milk-trucks, horse-boxes, and the like; between what points each coach works, what vehicles are to be picked up or taken off on the journey, and what special vehicles are to be run on certain days of the week. But the programme does more than this. It shows how each of the coaches is balanced on the return journey. Only local trains run through intact to their destination and return in similar fashion, whereas through trains soon get split up. Therefore it is necessary to work out how each vehicle returns, and to state the hour when it is due back. Trains must always be formed in the order shown in the programme, in order to determine the places on the platforms where the luggage and parcels are held in readiness.

Before a train leaves the carriage-sheds the gas reservoirs and lavatory tanks must be filled, clean towels and fresh soap placed in the lavatories, tail and side lamps put on, screw couplings, steam-heating pipe, brake hose, and communication cord properly fastened and arranged, and the gas lighted (except in the case of trains electrically lighted) on the by-pass if it is a night journey, and in the case of a day journey also if there are any tunnels.

Communication between Passenger and Guard. By the Board of Trade regulations every train that travels for a distance of 20 miles without stopping must be provided with a means of communication between the passengers and the guard. For many years this took the form of a cord running under the eaves of the carriage, which was wound up at the end of the train upon a drum in the guard's van, and at the other was attached to the handle of a special whistle on the locomotive. The notice ran: "To call the attention of the guard or driver, passengers must pull down the cord. There are cords on both sides of the train, but that on the right-hand side in the direction in which the train is travelling is the one by which alone communication can be made." Imagine, as a writer pointed out, the nervous girl, or even the average, self-possessed male, in the moment of danger, sufficiently collecting his or her thoughts to remember which was the right cord to pull, let alone the difficulty of reaching out to get at it! The southern lines were the first to improve upon the system. They adopted the principle of having two electric wires running through the train, like two sides of a ladder, which are joined together in each compartment by a rung that is broken in the middle. Draw out the bell-pull in any compartment, and the broken rung is instantly mended, the circuit closed, and a bell in the guard's van starts ringing.

Since 1901 the companies that formerly used it have adopted a standard train alarm signal, which consists of a valve, with a small passage that forms a whistle, and a rod passing through the valve to each side of the vehicle, and having a red disc attached to both ends. Near each end of the rod is also attached a lever, to which is connected one or two chains, usually two, which pass along the inside of the carriage immediately over the windows and doors of the compartments. The pulling of either chain by a passenger will be followed by a gentle application of the brake and the whistle being sounded. At the same time the red disc changes from a horizontal to a vertical position, and so indicates to the officials the carriage from which the communication has been made.

Train Working. The cleaning of carriages after a journey, and filling the axle-boxes with oil (for oil-boxes have almost everywhere superseded grease in the case of passenger rolling stock, and are now being fitted to the fast goods trains), devolves upon a cleaning staff, which, as a rule, comes under the locomotive and carriage department. Every passenger carriage at the end of a journey is as thoroughly cleaned, both outside and in, as time will permit—the floors washed, carpets shaken, and cushions dusted. The haphazard methods of cleaning coaching stock which were so long in vogue are now rapidly giving way to a more thorough and systematised plan, by means of which the work of getting rid of the dust which accumulates on the upholstery, floors, and other parts of the vehicle is expeditiously and searchingly performed. The vacuum system of extracting dust is largely employed, and the companies have built extensive covered sidings adapted for dealing with the vehicles in the direction of cleanliness and hygiene.

Before making a journey, all passenger rolling stock is inspected by train examiners, who, if they find any defect which does not affect the safe running of the vehicle, affix a green-coloured "For Repairs" label, while, if the vehicle is found to be so badly injured that it cannot be used, a red "Not to go" label is attached. Another class of examiners are employed in tapping the wheels with long hammers for the purpose of discovering fractures. Train-examiners and wheel-tappers belong to the locomotive and carriage department.

Refinements of Station Working. A few lines must be devoted here to several interesting refinements which have recently been adopted for smoothing the way for passengers. Information bureaus, where the prospective traveller

may obtain gratis all the information he needs, have been opened at the principal termini, together with writing-rooms, bathrooms, and dressing-rooms. Passengers can have letters, telegrams, and messages addressed to them here; and private rooms can be engaged for interviews. Train indicators have long been used to denote the respective platforms from which the different trains depart, and to enumerate the principal places served by the latter, but arrival indicators are a new feature. The latest kind of arrival indicator is electrically operated. It tells the time each train is due, the number of minutes it is late, the names of the principal stations at which it has called, and the number of the platform where it will be berthed.

Train Lighting. Improvements of a revolutionary character in the lighting of trains have come to pass during the last twenty years. Most of us can remember the primitive, vegetable-oil lamp, now happily a thing of the past. This was the earliest method of lighting railway carriages; and although it formed a byword of reproach on account of its feeble illuminating powers and general filthiness, while it entailed the employment of a special staff of lamp-men, a very long period elapsed before anything better was devised. Compressed oil-gas, with incandescent mantles, is now the standard illuminant for railway carriages.

Every railway company has its own oil-gas works, and the gas is conveyed from the works to the sidings, where the carriages are charged, in mains, to which valves and connecting hydrants are attached at suitable places. The storage cylinders, which hold about 100 ft. of gas and are fixed to the under framing of a carriage, are charged from the mains by means of flexible hose. However, gas cannot be consumed under the high pressure in which it is made, but has first to be passed through a regulator, which reduces the 150 lb. pressure to 1 in. of water, and admits gas at the same rate at which it is consumed in the single or duplex flat-flame burners. Each jet can be regulated, or all the jets in a carriage turned off or allowed to burn on the by-pass, by turning a key at the end of the carriage, while each carriage has a pressure gauge to indicate the pressure in the cylinders and the state of the supply. Non-"gassing" stations receive their supplies from travelling gas-tanks.

Electrical Train Lighting. Although oil-gas is the standard method of lighting railway carriages, a large number of trains are lit electrically. There are at least three methods of electric train lighting—namely, (1) lighting entirely by accumulators; (2) lighting by one dynamo for an entire train; (3) lighting by one dynamo fitted to each carriage. The two latter methods entail the employment of accumulators.

The third—namely, that of a separate dynamo and accumulators for each carriage—is the one which has been practically accepted as the standard method. The dynamo for generating the current is suspended from the under framing, and its pulley is driven direct by a belt from the pulley on one of the axles. As the lamps must be supplied at constant pressure, it is necessary to provide means to maintain the voltage of the dynamo constant over a wide range of train speed. This is usually accomplished as follows: after a certain limit has been reached, the dynamo always runs at a uniform speed and produces the same voltage, no matter how much the speed of the train may vary, which result is achieved by a compensating device attached to the dynamo. When the train is travelling very slowly, or is stationary, the lamps are fed from the accumulators alone, which are automatically connected to the dynamo by means of a mechanical governor. The accumulators are divided into two parts, each half acting as a regulator to the other, and, being always in connection with the lamps, the light remains perfectly steady.

Gas versus Electricity. There are many advantages, from the railway working point of view, in gas over electricity. The former illuminant is much less expensive. The maintenance of a gas-lighted corridor bogie carriage works out at about £6 a year, whereas with electric light the cost reaches about £45, as accumulators deteroriate very rapidly, vibration shakes the paste out of the plates, and the system of regulation by means of slipping belts absorbs a great deal of power. Further, at a high train-speed each dynamo will take as much as 8 h.p., so that on a main-line train of twelve coaches there is nearly 100 h.p. subtracted from the locomotive for light. The worst feature with such a system is that this power is absorbed whether the light is on or not. Then, the enormous weight of the equipment is another drawback. Each carriage carries a dynamo and two accumulator batteries, which, together with the automatic change-over switch, weigh more than a ton. Some new and better methods of electric train-lighting are now, however, being evolved. These are systems which avoid the slipping belt, diminish the weight of the equipment to three or four hundredweight, and claim to reduce the cost of maintenance per coach to about £10 a year.

Several terrible railway accidents between 1905 and 1913—in which gas-lighted trains were involved, and gas escaping from the cylinders under the wrecked carriages is believed to have ignited the wreckage—led to an agitation for the rejection of gas in favour of electric lighting. In 1911 the Board of Trade wrote the railway companies severally on the subject of the illumination of railway carriages, pointing out that from the standpoint of safety electricity was materially preferable to gas. The replies received showed that most of the large companies did not contemplate the adoption of electricity as the standard illuminant, and actual figures were afterwards given which showed that a wholesale conversion would absorb something exceeding £7,000,000. The Board of Trade presses still for the adoption of electric light, and it is certain that in course of time gas will be abandoned, the change taking place gradually. That the dangers of gas may be mitigated has been shown by the Midland and other comapnies, which have begun to decrease the diameter of the cylinders and fit them with a valve which prevents the egress of gas beyond a certain rate.

Heating of Carriages. The heating of carriages forms another phase of work associated with the comfort of the travelling public upon which much skill and ingenuity have recently been brought to bear. The rudimentary apparatus that long held the field was the foot-warmer—an oblong tin filled with water through an orifice, which was then hermetically sealed, and the warmer placed in a boiler until the water was heated. Like the vegetable-oil lamp, this cumbersome apparatus necessitated setting aside a special staff of men to fill, heat, and distribute. Eventually it was realised that an efficient, simple, and economical method of heating could only be achieved by mechanical means. Mechanical heating was first introduced into this country from America about the same time as Pullman cars [55, 69] by the Midland and Brighton companies, the system being that of high-pressure

hot-water pipes, fed from a boiler heated by a coke-stove. This method is still employed in a few sleeping-cars, but as it requires the constant attention of an attendant it is unsuitable for an ordinary train.

The "hot air" system, which was a modification of this "stove" system, was then brought into use. In this arrangement the air was driven by means of a fan over tubes placed in the fire-box or smoke-box of the locomotive, or over tubes containing steam at boiler pressure. This method was found unsuitable, air being a bad conductor of heat. The utilisation of the exhaust steam from the locomotive was also tried and found wanting.

The atmospheric or dry-steam storage system is now considered the best means of warming railway trains propelled by steam locomotives, being economical and satisfactory in operation and low in upkeep. The steam is taken direct from the boiler of the locomotive and passed to each carriage of the train by means of a main steam-pipe. From the latter it passes through a branch pipe to a series of storage heaters, one of which is found beneath each seat. A storage heater comprises a wrought-iron boiler tube, closed at both ends, and filled to seven-eighths of its capacity with a strong solution of brine. The steam is thus brought into contact with the interior tubes, whereupon the brine contained in the latter absorbs a part of the heat, which is then gradually given off at a lower temperature than would be the case with any method of direct steam heating at similar pressure.

A regulator affixed to the back or side of the compartment permits of a passenger shutting off the heat or readmitting it as desired. These heaters require no repairs; the strong solution of brine, of course, is proof against freezing, while the special form of steam-pipe coupling between coaches is unfreezable, absolutely steam-tight, and uncouples automatically when any two carriages are drawn apart. In order to obviate the discomfort of entering cold carriages, arrangements are made for heating trains at terminal stations before the engine couples on. A stationary boiler supplies steam to a main running alongside the platform, and this main is temporarily connected to the carriages at one or more points by means of flexible hose.

Electrical Heaters. Lastly, electrical heaters are occasionally met with in dining-saloons. The heaters are compact in form; there is nothing of a combustible nature used in their construction, and a free circulation of air against the heated wires is provided for. The heaters are fed from accumulators, which in turn derive their current from the dynamos, driven by belts attached to the axles.

Sleeping Cars. Although there is in this country of short-distance journeys nothing approaching the same extensive field for its employment as exists in America and on the Continent of Europe, the British sleeping-car is the most comfortable, the best equipped, and also the cheapest in point of the additional fee demanded for its use in the world. At present, sleeping accommodation is limited to first-class passengers, which is the rule almost everywhere, but it would not be surprising if we were soon to find an extension of such facilities to second and third class travel. An improved pattern of corridor sleeping-car has long been the standard on British railways. The car is divided into a number of state-rooms entered from the corridor. These rooms, as a rule, hold one berth—never more than two—some being convertible into one or two bedded compartments. The berths are arranged transversely, which position has been found to yield greater comfort than the longitudinal Upper berths, unpopular and rarely occupied, have quite disappeared. The bed is no shakedown affair, for its furniture comprises mattress, blankets, linen sheets, rugs, pillow, and bolster. Each berth compartment has its own washing-stand and other toilet fittings. The London and North-Western Company's latest sleeping-cars [**54**] are 65 ft. 6 in. in length, and carried on two six-wheeled bogies. They are electrically lighted, steam heated, provided with electric bells, a lavatory at each end, a buffet, from which tea, coffee, and mineral waters are served, and a smoking compartment, while a supply of hot water is among the toilet refinements. Notwithstanding their great weight—namely, 41 tons—they can accommodate only eleven occupants, each of whom, therefore, accounts for some 3½ tons of dead weight. Before 1903 the supplementary fee for all this luxury was but 5s. over and above the ordinary first-class fare. In that year, however, the northern companies raised the fee on the longer journeys to 7s. 6d. When a car arrives at a terminus earlier than 8 a.m., the occupants may remain in it until that hour.

Staffing and Stocking. A service of sleeping-cars is managed by the superintendent of the line, while the carriage department is responsible for preparing the cars for the road, and washing and mending the bed furniture. The stock of bedding kept by the North-Western Company comprises several thousand mattresses, mattress covers, sheets, rugs, pillows, and pillow cases. There are special halls at Willesden [**60**] where the bedding is kept aired and sorted ready for use. Every car is in charge of an attendant or conductor (wages 25s. per week), who attends to the comfort of passengers. He cleans their boots, brushes their clothes, takes charge of their tickets and collects excess fares, so that their rest may not be disturbed; serves them with tea or coffee, which he prepares in his pantry, and regulates the heating and ventilation of the car. The position of sleeping-car attendant is a coveted post, for naturally it carries with it perquisites in the way of tips. Only thoroughly intelligent and cleanly men of unimpeachable character are selected for the work, and, broadly speaking, they are promoted from among the ticket-collectors and head porters. The inmates of a car generally look to the attendant for help and advice concerning their journeys; hence the latter must be well acquainted with the time-table, and able to display an intelligent interest in the travelling affairs of those under his charge. For the benefit of those who are unable to afford the luxury of a "sleeper," pillows and rugs may be hired from the company, as shown in **61**. These articles are trundled about the platform in glass-covered barrows, so as to ensure perfect cleanliness before issue.

The Travelling Restaurant. Dining-cars were given to the world by America. As might be expected, their introduction has been largely responsible for the increased weight of trains. Cars range from 60 ft. to 70 ft. in length, and weigh from 35 tons to 40 tons [**58, 67, 71, 72**]. The small compass within which a host of articles in everyday use is carried on board ship is constantly quoted, but a far more remarkable system of stowage is observed on board a dining-car, where also the risk of breakage is greater. The kitchen [**70**] and pantry take up about a quarter of the length of the car, and from these confined premises a train like the Scotch express is sometimes called upon to serve 200 luncheons, 150 teas, and 200 dinners, all within the space of time of 8½ hours. The early kitchen-cars were equipped with coal-

stoves. These were subsequently superseded by gas-stoves, while the *batterie de cuisine* comprises a gas-grill, ovens, refrigerator, plate-heater, carving table, cupboards, sinks, and separate boilers for washing up and for making tea.

Organisation and Staffing. The dining-car business has now attained such vast proportions that it necessitates the employment of a special organisation and staff. Most companies place the management and catering of the cars under the chief of the hotels and refreshment department, while one at least has a special officer who, although

68. STEAM RAIL MOTOR-CAR ON G.N. RAILWAY, WITH DETACHABLE ENGINE

he draws many of his stores from the hotel department, otherwise works independently of the latter. Under the hotel chief is a salaried officer who acts as maître d'hôtel to the dining-cars. He may be seen inspecting cars before a train starts, to satisfy himself that all is in order. The staff of a car consists of page attendants, second attendants, a head attendant or conductor, a kitchen porter, a carver, and one or two cooks. The staffing of the cars may be described as an Englishman's job. Without exception, the companies refuse to engage foreigners to wait upon passengers, while some give preference to English cooks. Lads are taken as page attendants between the ages of 14 and 15, and if they give satisfaction they are certain to become head attendants in time. Adults are also engaged as attendants, but the choice of such is practically limited to men who have been waiters in the company's refreshment-rooms or footmen or butlers in private families.

The head conductor or attendant is responsible for the provisions, which are invoiced to him, also for all stores, wines, and the like, while the service staff generally is charged with the cleanliness of the cutlery, linen, and plate.

Provisioning. The provisioning of cars is arranged for at terminal and important intermediate stations. Broadly speaking, the food is cooked on the train, but prepared beforehand. Thus, soups and sweets have only to be heated up, whereas fish and joints have to be cooked while the train is travelling at full speed. The Great Central procedure is to have all the food brought aboard direct from the vendors—the fish from the fishmonger, the game from the poulterer, and so forth—and handed over to the dining-car chef direct. At Euston there is an array of culinary offices, under the supervision of a head chef, who draws up all the menus for the day. In one kitchen sweets and soups are being prepared; in a scullery vegetables are being washed; in a larder joints are being cut up and fish prepared; in a stillroom groceries, pickles, cheese, and fruit are being made into parcels; and in a linen-room maids are checking linen home from the wash, and mending it. All the comestibles for each car, together with a separate package containing tablecloths and napkins, are packed in a large hamper, which has just been steam scoured, and despatched to the proper train. Dining-car cooks form a distinct class, which has come into existence during the last fifteen years. A cook who joins without experience is sent for a week or so up and down the line in company with an old hand to learn his business.

At the end of a journey a car is gassed and watered by the carriage department, which is also responsible for cleaning all parts of it except the kitchen and pantry, this latter task being the duty of the car staff. Some companies have very stringent rules relating to the removal of any food left over, the penalty being instant dismissal if so little as the tail of yesterday's sardine be found in a car on the following morning. The washing of the soiled table linen sometimes falls to the carriage department, and sometimes to the hotel department. By aid of the invoice system it is possible to ascertain exactly how each car is paying. Dining-cars are now a profitable enterprise, but they are not run with the idea of making big profits, the management being quite satisfied if they just pay their way. Most companies now serve à la carte refreshments, except during the service of meals.

Refreshment-room Catering. The majority of railway companies have taken over the ownership, management, and catering of all station refreshment-rooms. In doing so they have been actuated not so much by the desire to establish a fresh source of revenue as to study the comfort and convenience of passengers. It was found that private ownership sometimes led to abuses. It goes without saying that the management and staffing of the refreshment-rooms is a large business of itself, but, as it cannot be said to form a part of the railway industry proper, it need not be described. One new and welcome feature may, however, be noted. The spread of restaurant-car facilities, perhaps, has pampered the travelling public. At any rate, the more enterprising companies have come to the conclusion that, in the case of non-restaurant-car trains, it is good business to bring the refreshment counter to the doors of the carriages, and so obviate the necessity of asking persons to leave the train and walk a few yards. The travelling refreshment-stalls inaugurated by the Midland do this [48]. Equipped with boiler, urns, and ice-safe, they perambulate the platform, and serve out tea, coffee, soup, and the like, freshly made.

The Advantage of Rail Motor-cars. The employment of what are called *rail motor-cars* is a very remarkable development that has taken place on British railways since 1903. From the outset the enterprise was attended by marked success, inasmuch as it at once proved its ability to solve easily some of the problems of the traffic manager. At the present time there is scarcely a railway of importance which has not adopted this new type of vehicle, containing its own motive power.

The idea of rail motor-cars is that they furnish better accommodation, and secure more economical results in working the passenger traffic under certain conditions, which may be enumerated as follows: first, in the case of suburban traffic which encounters competition on the part of electric tramways, the rail motor-car enables a railway company to afford facilities for cheap and rapid transit during those periods of the day when the number of passengers to be carried does not warrant the running of heavy engines and long trains, these latter

being reserved to meet the stress of the morning and evening traffic. Secondly, where the rural branch lines are concerned, the rail motor-car can be used to fill a void by giving a more frequent service than it would pay to do by means of ordinary trains. The general manager of a railway company largely employing such cars for this particular purpose states that the cost of running a steam rail motor-car as compared with a train is as 5½d. for the former per train mile, as against 1s. 3d. for an engine, with four coaches, per train-mile. By means of rail motor-cars, therefore, both the railway company and those residing on branch lines benefit, while, as the cars can also be used to stop between stations, at level crossings, and at other places where roads are close to the railways, they give access to districts which formerly laboured under the disadvantage of being situated some distance away from a station. These intermediate stopping places are called "halts," and it is only necessary to furnish them with a low platform and a small waiting-room.

Different Patterns of Cars. It is not possible to describe all the various patterns of cars now in use on the different railways, but the principal points of distinction between various types may be touched upon. From the road automobilist's standpoint, the term "rail motor-car" is, however, somewhat of a misnomer, as it gives him the impression that these cars are operated with an internal-combustion engine, consuming petrol, whereas there are only two or three instances of this kind of engine being adapted to rail motor-car work.

The internal-combustion engine, as a rule, is not sufficiently flexible for railway exigencies. The necessary high acceleration cannot be obtained with it unless it is made impracticably large, while it cannot respond to overload. On the other hand, it requires much less space for the storage of fuel. At present the vehicles are divided into three classes: (1) steam-operated; (2) petrol-electric-operated; (3) petrol operated by means of an internal-combustion engine.

Common Characteristics. A steam-driven rail motor-car combines on one frame an engine and a passenger car of moderate seating capacity, the total length of the vehicle varying between about 55 ft. and 70 ft. The car is carried on two four-wheeled bogies, that at the trailing end being usually a standard passenger-coach bogie, and the other forming a four-wheeled outside-cylindered locomotive of small dimensions. Sometimes the locomotive is complete in itself [**68**] when detached from the car frames, and may, if required, be run separately for shunting purposes, which are almost indispensable in railway working, while in most other cases the engine bogie is detachable [**49**], and the boiler and chimney can pass through an end door, in order that a defective engine can be replaced. The engine can always be operated from either end of the car, by means of a duplication of the stopping and starting apparatus, whistles, vacuum, steam and hand brakes, for the essence of a rail motor-car is that it can be worked as a shuttle—that is, without having to be turned round in order to keep the engine foremost. A special arrangement provides that the vibration from the engine body is not transmitted to the body of the car.

Types of Boilers and Valve Gear. There are several different types of boilers—namely, a smaller pattern of the ordinary locomotive type of boiler, with or without a Belpaire firebox, and carried horizontally; a vertical multitubular boiler, which kind is the most popular; and a novel generator of the vertical type [**50**]—namely, Cochran's patent boiler. This last possesses a minimum of joints and welds, and has no rivets or welded joints in actual contact with the fire. The feature, however, which affords pre-eminence is the facility that is afforded by the boiler design for obviating internal scaling. Scale formation is an important factor in the life of any boiler under all and sundry conditions. Failure by burnt plates or tubes, and consequent early scrapping of boilers, generally arises from inability to get at the interior so as to clean it effectively. The accessibility of all parts of the Cochran boiler for the latter purpose forms its chief claim to consideration. Sometimes the valve gear is worked by ordinary eccentrics, which are fitted on the driving axle instead of on the frame, and which actuate the valves on the top of the cylinders by means of a rocking shaft from ordinary link motion. More often, however, the cylinders are actuated by the Walschaert valve gear. Sufficient water is carried for the service in a tank or tanks placed below the carriage body, and there is also room for a supply of fuel in the motor compartment or elsewhere.

Arrangement of the Carriage. The carriage itself is divided into two or three saloon-like passenger compartments [**62**, **76**], a guard's and luggage compartment, and a driver's compartment at the opposite end to the engine-room, all having free internal communication, while the entrance to the car is sometimes effected by gangways fitted with "lazy tongs" gates. Electrical communication or speaking-tubes are furnished between the driver's and guard's compartments. For convenience in stopping at "halts" at which no platform is provided, there are steps on each side of the car, which can be either covered by hinged flaps when the car draws up at an ordinary platform, or swung back to the width of the ordinary footboard by a lever. With some cars the outward movement of the steps opens a valve in the main vacuum pipe, and so prevents the car from starting till the steps are locked in running position.

Petrol-electric Cars. The North-Eastern Railway employs a few petrol-electric autocars [**51**], in which the generating power is a four-cylinder petrol engine, 80 b.h.p., that drives a dynamo direct, which in turn generates current for four electric motors, one on each axle of the vehicle.

The Great Central Railway is experimenting with a 90 h.p. type of petrol-electric car, the engine of which operates on the four-cycle principle, and has four cylinders. Two motors are employed, driving on the axles of the rear bogie, each rated at 64 h.p. A separate petrol set is used for operating a vacuum brake exhauster, and driving a small generator, which serves for providing electric lighting of the coach. The Great Western has also embarked on petrol-electric rail motor-cars [**57**, **76**], employing a type in which a 40 h.p. engine drives a dynamo, which transmits power to two motors. Notwithstanding the light weight of the vehicle, 14 tons, it accommodates 44 passengers, the weight per passenger, therefore, working out to only 6 cwt. 1 qr., as compared with about 13½ cwt. for the steam rail cars in use on this railway. A great future is predicted for the petrol-electric system, which not only obviates those disadvantages already noted of the purely petrol engine, but dispenses with the gear-box and clutch and attendant complications. Of course, the drive may be made from either end of the car, and one man is sufficient for attending to the engine and for driving, thereby saving the cost of the additional man needed for stoking in a steam-propelled vehicle. The control of the car is what

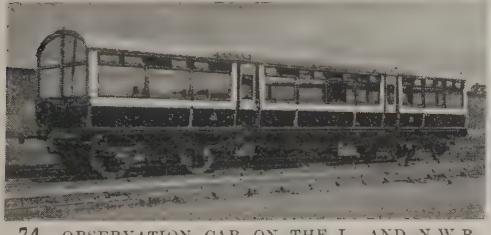
69. A PULLMAN VESTIBULED TRAIN ON THE LONDON, BRIGHTON, AND SOUTH COAST RAILWAY

70. KITCHEN OF A RESTAURANT CAR ON THE G.E.R.

71. A PULLMAN RESTAURANT CAR ON THE S.E.R.

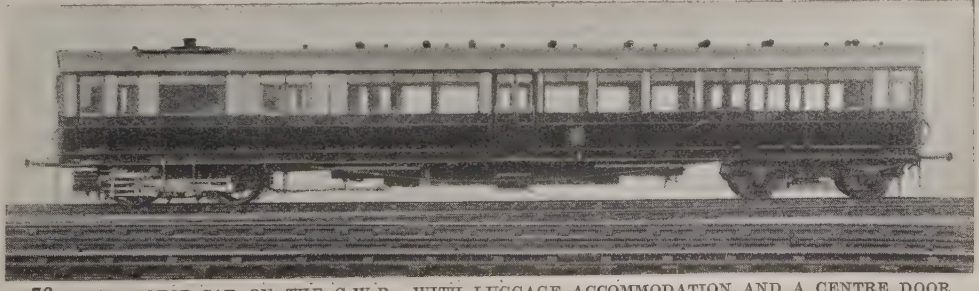
72. PULLMAN RESTAURANT CAR ON A S.E. AND C.R. EXPRESS

73. ELECTRIC AUTOCAR ON THE N.E.R.



74. OBSERVATION CAR ON THE L. AND N.W.R.

75. INVALID SALOON ON THE N.E.R.



76. RAIL MOTOR-CAR ON THE G.W.R., WITH LUGGAGE ACCOMMODATION AND A CENTRE DOOR

is known as "dead-man's handle," which renders it necessary for the driver to hold the controller handle continuously; if it should be released, the energy would be cut off from the motors.

Petrol Cars. These have been tried on several lines, but so far without much success. The vehicles are smaller than any of the steam and petrol-electric cars, and are carried on four wheels. Provision is made for two speeds in each direction. Strenuous endeavours are being made to evolve an autocar on this principle suitable for railway purposes. It is realised that there is wide scope for the employment of light, self-propelled vehicles.

"Trailers." The seating capacity of a steam rail motor-coach varies, according to its size, from 50 to 64 passengers. The more powerful cars [57] are capable of hauling a "trailer" coach, and they are also calculated to attain a speed of 30 miles per hour within 30 seconds of starting, while but few cars are designed to run at a higher rate of speed than 45 miles per hour.

Before ending the description of rail motor-coaches, mention must be made of a later development upon the same lines. Several companies have fitted small side-tank engines to work with "trailer" cars as complete units. Engine and coach are never uncoupled while in service, and duplicate gear in the driver's compartment of the coach, at the end farthest from the locomotive, enables the unit to be worked either end foremost.

Management and Staffing. Rail motor-cars are under the control of the chief mechanical engineer, which he exercises through the district locomotive superintendent in precisely the same way as he looks after engines. It is not improbable, however, that as the employment of the cars becomes more extensive, a special department will be called into existence for the purpose of supervising them. A feeling is growing that since rail motor-cars constitute what is an essentially light, rapid, and mobile form of traffic, they require something less ponderously inclined than the brains of the locomotive department to study their needs and devise technical details.

The staffing of the cars is as follows. The steam-propelled vehicles require the services of both a driver and a fireman, as there must be a man in charge of the boiler. Therefore, when a car is running engine-room hindermost, the men part company, the driver being in the motor compartment in front (which, it will be remembered, is equipped with duplicate controlling gear), while the fireman remains behind. Some companies make the fireman act as guard or conductor as well, but the general practice is to employ a third man. The duties of the conductor of a rail motor-car are the same as those of a passenger guard in seeing to the needs of passengers, looking after luggage, and attending to the safety of the "train." In addition, he often issues and collects all tickets, and, when the car stops at a "halt," acts as the stationmaster, porter, etc., of that "halt." The operation of a car fitted with an internal-combustion engine can be entrusted to one man, the driver or motor-man, a fireman being unnecessary. Drivers or motor-men, together with the firemen of rail motor-cars, are drawn from the staff of engine-men. Conductors are selected from men who aspire to become full-fledged passenger guards; in fact, this service is now regarded as a training field for the latter.

Passenger Road Motor Traction. The functions of passenger road motor-cars are, broadly, to act as feeders to the railways, and so to promote travel in every capacity, while, incidentally, they also serve to exploit tourist districts, to form an efficient substitute for light railways, and to render possible a complete service over a new railway route, starting from railhead, pending the completion of the construction of the line.

Practically every railway-owned passenger road motor vehicle is petrol-driven; among the different types of bodies used are: (1) double deck omnibus; (2) single-deck omnibus [63]; (3) observation or char-à-bancs [65]; (4) open waggonette; (5) composite goods, mail, and omnibus. Each type of vehicle has accommodation for a certain amount of passengers' luggage, together with parcels, and many of them also make a speciality of the conveyance of packages containing agricultural produce, so that a service may fulfil an additional purpose in the way of bringing markets nearer to producers, or of opening up to the latter new areas of supply.

Passenger Tickets. Passenger tickets comprise: (1) ordinary tickets, issued for ordinary trains at ordinary fares; (2) blank card tickets, used for light traffic only—that is, where there are few passengers between a pair of stations in a month, and on which the name of the destination station is omitted; (3) tourist and week-end tickets at reduced fares; (4) excursion tickets, printed specially for each excursion; (5) circular tour tickets, which take the form of booklets of coupons; (6) market, fishing, golfing, hunting, etc., tickets at reduced fares; (7) periodical, season, or contract tickets, which are specially printed, and require, as a rule, the holder's signature; (8) officers', soldiers', seamen, and police tickets, at reduced fares, which are kept in books with counterfoils, and which are issued on the production of orders signed by the proper authorities; (9) workmen's tickets at reduced fares, which are available only by trains running at specified hours; (10) pleasure party tickets, which save stamping, say, 150 separate tickets to the members of a school treat; and (11) privilege tickets, issued to the company's servants. Further, tickets for the conveyance of dogs, bicycles, perambulators, or any other articles carried at owner's risk, are issued at the passenger booking-office.

Manufacture of Railway Tickets. Some companies print their own tickets, and others contract for them, while some do both; but in all cases the printing establishment is under the close supervision of the company's accountant, who exercises a constant check on the supplies.

The manufacture of railway tickets as carried out by the London and North-Western Railway at Euston Station may be described as a representative process. The first room entered is where the multicoloured sheets of pasteboard are received from the papermakers, and where the sheets are stored, and passed through machines which cut them up into the little cards with which we are so familiar. The first machine snips off the rough edges, and divides each sheet into a number of longitudinal strips of the required breadth, while the second machine is fed with the strips, and cuts each into so many cards of the correct length. The cards issuing from the latter machine are ready for printing, and are carried by tray-loads into an adjoining—the composing, printing, and counting—room.

Ingenious Automatic Machine. Great ingenuity has been brought to bear in the perfection of ticket-printing machines. The latest patterns may be described as being self-acting in every respect. The blank cards are fed into a hopper on one side, whence they descend and

pass through the machine in an endless stream so long as the supply lasts, one card pushing the other forward. In the body of the machine each card is impressed with its proper consecutive number; has its face printed with the names of the issuing and destination stations, class, fare, etc.; is then turned over so that its reverse side may have imprinted on it a short notice beginning "Issued subject to the company's regulations," after which it is turned face uppermost, preparatory to leaving the machine by another and similar hopper, in which the column of finished cards is pushed upwards. These machines can print from 10,000 to 14,000 tickets per hour. The supply of ink is automatically fed to the rollers; and in the event of a slightly torn or crumpled card being encountered, the machine stops of itself, and declines to continue printing till the offending specimen has been removed. Lastly, the printed tickets are passed through a machine which automatically counts them in batches of 250 at a time, and records the total number which has passed through it. Here, again, the cards are placed in a hopper, and the attendant turns the handle of a dial to the number borne by the first ticket to enter the machine. The machine is then set going, and automatically stops when it has counted out 250 cards into a hopper below. The attendant must see that the dial records exactly that number, and that it tallies with the number of the last ticket, otherwise one or more tickets must have got lost, or duplicates as regards the successive numbering been printed, in which case very careful search has to be made to rectify the error, for a printed ticket is treated as representing its face value in cash. The latest type of counting machine can deal with 20,000 cards per hour.

Number Check on Tickets. The company's audit accountant is the only officer through whom passenger tickets (save, in some cases, season tickets, which are supplied by the general manager) may be obtained by the clerks in charge of the booking-offices.

All tickets are type-numbered consecutively at both ends from 000 to 9999 inclusive (to avoid printing five figures when the limit of 10,000 is reached), and are marked to indicate the "series" to which they belong, ten thousand of each kind, class, and station making a "series." By the Regulation of Railways Act, 1889, Sec. 6, the fare must be written or printed on every *ordinary* ticket. The different colours and distinctive markings assigned to the tickets for various classes and specific purposes are legion, while there is a curious want of uniformity among companies in the colours that distinguish the classes.

Booking Offices. Inside the booking-office, the tickets are kept in rows of "tubes" so called—really two pieces of wood joined by a spring—which tubes are contained in lock-up cases of various sizes. The name of the destination station and fare is written above each tube, and the number of the next to issue is written on a strip of slate below the tube. The system is to place tickets in the tubes with highest numbers at the top, and, when booking passengers, to draw from the bottom, so that, after the departure of a train, by deducting the number written upon the slate from the number on the next to issue, it is readily ascertained how many have been issued by that train. Below the lock-up cases are chests of drawers containing bundles of tickets to replenish the tubes. At large stations the arrangement of the booking-hall is very methodical, the apartment being divided into classes and districts, with a separate window for each, while the case containing tickets most frequently used is placed nearest the window, and the remainder branch out in geographical order.

77. A GREAT CENTRAL EXPRESS ENGINE TAKING UP WATER

Renewing Stock of Tickets. Here, too, the staff comprises not only clerks to issue tickets, but a ticket stockkeeper, a cashier, and a chief booking-clerk, each of whom has his own office within an office. The stockkeeper periodically replenishes from his own stores the drawers below the lock-up cases; and when he finds that a series of one class between a pair of stations is nearing exhaustion he fills in a "Ticket Demand Note," specifying the name of destination station, route, colour, class, description, fare, number of ticket which will be issued last, and the last progressive number of tickets in stock.

This demand note is signed by the chief booking clerk and sent up to the accountant's office, where it is checked and compared with the ticket stock registers. Each issuing station has an account in the stock registers, and the following particulars are inserted in their proper columns: name of each destination station, route, class, description, date of demand, last progressive number of tickets

supplied, and quantity supplied in bundles of 250, and date of last supply.

Booking Clerks. Immediately after the departure of each train, the "train-book" is made up, showing an account of tickets issued, a separate entry being made for each station and class. The "beginning number" is copied from the slate, and the "closing number" from the ticket next to issue, while the number of each blank card ticket issued has to be entered separately. After the train-book has been made up, the old "beginning number" is wiped off the slate, and the old "closing number," now the "beginning number," written up in its place, when the clerk begins booking for those stations again.

At the close of the day a "proof sheet," or daily classification book, is made up, giving an account of every ticket issued, but before attempting to balance the day's takings the number of tickets that has been issued is balanced in a "Taking Out Sheet." At intervals during the day the clerks have been paying in "on account" to the cashier of the booking-office, and on the following morning, between 9 a.m. and 10.30 a.m., the whole of the takings of the day before are paid to the chief cashier in the accountant's office, and there balanced with the daily classification book.

Checking the Receipts. The takings and tickets issued by each individual clerk are made up separately, so that any individual loss or surplus may be located. The foregoing is the procedure followed at the great terminal stations, where on certain days of the year—the eve of a Bank Holiday, for instance—the number of tickets issued runs into tens of thousands, while the cash receipts total thousands of pounds. And the same system applies on a more or less modified scale, according to its importance, at every issuing station on the railway. At ordinary stations, the stationmaster is responsible for the work of the clerks, and at small stations he issues the tickets and makes up the books himself. For the collection of cash receipts and used tickets, the line is divided into districts. Specially constructed safes travel up and down the line between district headquarters by passenger train, and into these receptacles the stationmasters of intermediate stations place their takings in bags, for which the guard of the train signs, while leather cases containing the collected tickets are also delivered into his charge.

At the district headquarters the cash is banked as soon as it is received, while the account-sheets and collected tickets are forwarded every month to the chief audit office. The daily classification books are not sent up to the audit department, but at the end of each month the whole of the beginning numbers are taken off from the tickets themselves, and worked out on the month's issue. This monthly total must balance with the totals of the daily classification books.

The Monthly Audit System. The task of getting out the monthly audit of the receipts from all coaching traffic is very laborious, and necessitates the employment of a special staff of clerks and ticket-sorters, the latter consisting of boys, or sometimes women. Each collected ticket has to be sorted back into its proper series of kind, class, and station, and a note taken of missing numbers and tickets irregularly issued. Directly the monthly audit is completed, the sorted tickets are defaced and destroyed. Schedules of tickets missing are sent every month to the station responsible, for an explanation, and, should the number be unusually large, an investigation is ordered.

Automatic Ticket-printing Machines. The ordinary ticket system has certain disadvantages from the standpoint of the issuing clerks. For example, if a clerk issues in error a ticket out of its numerical order, he has to account for all numbered below it; and it also makes accounting of tickets a long and troublesome business. Attention is now being given to the subject of automatic ticket-*printing* machines (not to be confused with automatic ticket-*issuing* machines), to be operated by the booking-clerks themselves at the stations. These machines obviate the need of storing printed tickets, which takes up a great deal of room, and do away with all the risks of fraud and loss which the old system invites. The Great Western was one of the first companies to employ such machines. The machine in question can print tickets for as many as 2000 destinations. It consists essentially of an octagonal roller, bearing the names of the various stations, and a moving carriage, containing the actual printing apparatus, and rolls of paper for recording the transactions. When asked for a ticket, the clerk inserts a blank card into a slot in the carriage, and then slides the carriage so that the position of a pointer with regard to the roller indicates the destination and class for which the ticket is to be printed. The clerk next moves a lever, and the printed ticket is ejected from the slot. Simultaneously with the printing of the ticket, the transaction is recorded in duplicate on control strips, consecutive number, fare, class, and destination, the latter being indicated by a number, and not by name. One of these strips the clerk can remove from the machine, and paste into the train-book. He is thus relieved of the work of account-ing. The other strip is inaccessible to the clerk but is removed by the auditor in due course.

Training of Booking Clerks. Booking-clerks, as a rule, begin to learn their duties as boy clerks or boy ticket-sorters. Promotion in this branch of the service depends entirely upon intelligence and merit. A smart clerk knows the geography of his line backwards, so to speak, has hundreds of fares in his head, and is a lightning calculator of ticket sums. Another important qualification for a booking-clerk is an unruffled temper. Pertinacious inquirers about subjects which have no concern with the issue of tickets have to be persuaded to move on, and no notice must be taken of the remarks of irritable or ill-conditioned travellers who air grievances against the company on the "man behind the pigeon-hole."

To ease the labours of booking-clerks during the "rush" hours, automatic ticket-issuing machines have been adopted by the Great Western, North London, and Metropolitan Companies.

Ticket Nipping. There is a good deal more in the nipping of tickets by examiners than meets the eye. The practice has a two-fold object—to deface the cards so that they shall not be used over again, and to mark them by impressing a number or punching out a sign or letter, in order to afford evidence of the right of companies to claim a proportion of the through fare when passengers have travelled by a route different from that for which the tickets were issued, or to prove how far a passenger had travelled in the case of a refund claim. A different number or mark is fixed by the Clearing House for each junction or principal station, or group of minor stations, a record of the same being kept there.

H. G. ARCHER

Two and Three colour Work. The Forme. Machines. Make-ready. Progressive Proofs. Paper and Inks. Bronze Printing.

COLOUR PRINTING

We have shown in the last chapter how the three-colour copper blocks (yellow, red, and blue) are made from the originals supplied to the process engraver. As, of course, it would be impossible to print very long numbers direct from the original blocks, mainly for the reason that it would take too long and be too expensive a process, we must next show the usual methods for providing the printer with a number of originals. These can be either electrotypes or, as is now adopted in general practice, fine-art stereos made by the Dalziel plaster process [see page 4691]. The actual number of stereos or electros used on a machine is governed by the size of the bed of the machine, and by the size of the job and paper obtainable. The largest sheets usually employed are about quad-crown (30 by 40 in.), this size being more than sufficient to accommodate eight sets of plates giving at view pages 1 and 4 of any of the standard magazine covers, such as "My Magazine." This allows for the necessary margins for the locking-up clips on the machine-beds, and tapes and bands for securing better register by holding sheets close to the cylinder during the actual impression.

Making Up. The *forme*—as the plates on the machine-bed are called—must now be dealt with in detail. The most usual method employed nowadays for making up the electros or stereos into a forme is as follows: an iron bed with grooves into which clips, made up of three parts—the bottom, top, and screw—wedge tightly on a screw, is used, and when tightened up is undoubtedly best from all points of view; it holds plates most securely, yet the register is very easily adjusted, and, furthermore, a bed of this type gives a good, sound impression, and if the clips are in good condition and properly tightened up the plates do not *drive*—shift their position—and detrimentally affect the register. These mounting beds are made in various sizes to suit the different sizes of presses. [See page 5586.]

Colour-printing Machines. Accurate register is essential in good colour-printing, and to get the best results a press should be used for each colour. For the lighter class of two-colour subjects quite good results are obtained by using a two-revolution two-colour press. In these presses both formes are on the one machine, which is provided with a separate cylinder, rollers, and so on, for each colour, the sheet being transferred, after the first impression, by means of a drum and grippers, to the second impression cylinder.

Two-revolution presses are also generally employed for the printing of three-colour letterpress work. This type of press, as stated on page 4822, derives its name from the fact that the cylinder revolves twice to one impression, rising and falling alternately, so that the forme is inked during one revolution, while during the other the sheet is actually being printed, and delivered into the taking-off boards. One of the earliest machines of this type, and perhaps the best known throughout the trade, is the Miehle [see page 4823]. This press originated from the United States, and there are some that have been running in this country day and night for the past sixteen years, and are today still doing good work. For many years past, however, the Miehle has been made in this country, at Broadheath, Manchester.

Other presses very suitable for colour work are the Optimus, sold by Messrs. J. Haddon & Co., and the Huber-Hodgman. As was noted on page 4822, two or three Miehle machines are placed in tandem, and the sheet passes through the machines in succession, the yellow generally being printed first, the blue second, and the red last.

To get the best results from a Miehle, as from any other high-class machine, it must be carefully looked after and thoroughly adjusted at frequent intervals by an experienced man; if this is not done, bad register, which is fatal to good colour-printing, will result. Some of the details which make for the success of this press are as follow: it is easily adjusted throughout, it has microscopical front and side lays, a solid impression, a face-up gripper delivery which prevents smearing, and the forme is readily accessible without disturbing any other part of the press.

For short runs of, say, 1000 or so, it is usual to print from original blocks on any of the up-to-date platen presses.

Dressing the Cylinder. The cast-steel cylinder is *dressed*. Its edges run on bearers on the bed of the machine, which are accurately adjusted to type-high—·918 in.—but the main body has to be covered with packing make-up of glazeboard, linen sheets, manila sheets on which to stick the overlays, and other sheets to suit the particular forme being worked. All these are covered up with a manila, which is fastened tightly, usually being wound round a bar. The formes having being placed on the machines and cylinders dressed, a sheet is printed on each to give the machine-minder an idea as to what amount of underlay is necessary. This, of course, varies according to the subject and the class of paper being used.

Underlaying. An underlay is made from *pulls*, or proofs, of the block, and is used to level up the forme; in some cases, however, it is necessary to reverse this process, and thinning of the plate by scraping has to be resorted to. When dealing with vignetted work, good results can be obtained if the electros or stereos are undercut at the edges of the vignettes, in the same manner as are the original copper blocks.

Underlaying must be done carefully, especially when dealing with light screen-work, as this has always a tendency to work up heavier on the run. The forme having been underlaid, the next procedure is to fit up tapes in margins (as previously mentioned). Then, to secure register, sheets are pulled from the key forme, which is usually blue; and, the furniture and imposition having been passed, plates of the other colours are moved to register with the blue.

Overlays. Register having been obtained, the overlays and making ready are next proceeded with. Overlays cut by hand, when cut by an experienced man, undoubtedly give the best results; quite good results, however, are obtained with the mechanical chalk-relief overlay. This kind of overlay is especially useful when a large

number of sets of one plate are being worked from; furthermore, it is cheaper to produce, especially if there is sufficient work to keep the operator employed all the time. A special coated board is used for these overlays, which is printed on both sides with special ink, on one side direct from the block, on the other by rubber offset process. The card is then etched in a bath of chloride of lime, the solids remaining, and the high-lights and half-tones graduating away according to the amount of ink deposited. Where the ink is solid, the etching fluid will not eat away.

Making Ready. An impression having been made on a tightened-down sheet on the cylinder, the overlays are stuck up to register with this impression. The smallest amount of paste possible should be used, as otherwise lumps will form, and will spoil the result of the overlay. The cylinder is again covered up with several sheets; the quantity used must be sufficient to make up the correct radius of the cylinder. A sheet is now pulled again, to make sure that the overlays have been correctly put up. When all in this direction is right, a further thin sheet is pulled as a guide to the making ready for the letterpress. This is patched up with tissue paper on the back, and any parts that are too heavy cut away. Two further sheets should now be pulled, from which to cut out further thin overlays. These should be stuck on to a making-ready sheet, and the whole put up together in pages. The cylinder having been covered over with a tight sheet, an impression should be pulled on the cylinder, and any final touching up of weak places done thereon. The cylinder must be covered up with the requisite number of sheets, to make up proper circumference, and finally with a tight manila sheet.

GROOVED IRON MOUNTING-BED FOR PLATES
By courtesy of Messrs. Hunters, Ltd., London

Colour Proofs. The making ready having been completed, the colours should be run up and sheets pulled from each press, to make sure that the register is sufficiently correct to enable yellow to start printing.

Progressive proofs—that is, proofs pulled in colour from each of the original blocks—are taken, the yellow being pulled in black as well as yellow, to enable the printer better to judge the strength of block, the red being pulled separately and on top of yellow, the blue separately and on top of red and yellow again. This gives the finished picture. This is the printer's guide, and he must match each colour individually. There are, however, exceptions to this rule in this matter. Progressives are usually pulled on best quality pure white coated art paper, but the paper used for printing the job is usually somewhat inferior, and, what is most important to the printer, it frequently varies in tone from that of the proof. Where this is the case, the printer must depart from the progressive colour-proofs supplied, and use a set of colours that he considers will give him a finished result equal to the proof.

Inks. The usual course adopted with regard to inks is for the printer to submit to his inkmaker a set of progressive proofs and a sheet of the kind of paper that is being used for the job. It is then open to the inkmaker to send in a series of colours that will give a satisfactory result. Inks should be supplied by the maker in such consistency that they can be worked in their full body. If inks are too stiff, they will pull the surface of the paper, and probably dry on the rollers. It is inadvisable for the printer to do much in the nature of reducing the inks. Should it be absolutely necessary, he should use a reducer supplied by the inkmaker, as reducing with oil and the like will take the body out of the ink, and the colour will dry very flat. The difficulty may often be overcome by placing an electric stove under the ductor; the heat somewhat softens the ink and make it work more freely.

Inks that are required for use on three-colour work must be specially made for the purpose, in order that the colours shall blend properly. If ordinary colours were used, one colour would not blend with another, as there is not sufficient transparency in them. Inks vary much in their nature of origin, some being mineral and others vegetable and chemical. [See INK, pages 4826 and 5075.]

Paper and its Treatment. The paper used for three-colour work in particular, and also for any colour register job, must be well seasoned, otherwise there will be contraction and stretching during the interval between the printings of the colours.

Coated art papers are chiefly used for colour printing because, having a highly polished surface, they show a good finished effect. Art papers vary very much in quality. Care must be taken in the handling and storing of art papers. They should be stored in a dry atmosphere, preferably at the same temperature as that of the press-room. Should paper be exposed to various atmospheric changes, it will undoubtedly give trouble in printing, both from register and the lifting of the surface. Care must be taken not to make breaks and creases in the paper when handling, both in the warehouse and between the printing of the colours, as this causes set-off and the depositing of the enamel on the forme, which, if not quickly removed, will spoil a number of sheets. It will be readily seen, therefore, that progress with the printing will be very slow if the paper is damp and peels badly, as the machine must frequently be stopped to clean the plates.

Some printers hang their paper for colour-work in half-quire lots; this is the best method to ensure paper being thoroughly seasoned, and consequently good register results. Of late years a dead-finished art paper has been on the market, but it is more used in the United States than in this country.

Bronze Printing. Gilding or bronzing is accounted one of the fine arts of printing. The process usually adopted for bronze or gold printing is as follows: the make-ready is as for ordinary letterpress work, but a special ink, called a *gold preparation*, is used, which is a kind of yellow-buff ink. The wet sheets are then dusted over with a pad dipped in bronze powder. In houses where much bronze-work is done, machines for depositing and for dusting off the bronze powder are used.

Of late years gold inks have been on the market, but, although simplifying the process, they do not give quite as bright a result as the ordinary method of bronzing explained above.

F. S. CATHIE

History and Statistics. Conditions of Service and Qualifications. Training. The Work of Junior and Senior Assistants. The Work of a Librarian. Organisation of the Profession.

THE PUBLIC LIBRARIAN

Growth of Libraries. The municipal public library, in the English and American sense, is a speciality of Anglo-Saxon peoples. Only in recent years has anything of the sort existed on the Continent, and those which do exist are based more or less on English or American lines. These institutions are purely modern, even in England, dating no further back than the middle of the last century. It is true that there were free libraries in England in the early part of the seventeenth century, but they were due to private benefactions, were extremely limited in scope, and were not supported by a library rate. The rate-supported public library was created by an Act of Parliament passed in 1850. The man who introduced it was William Ewart, M.P. for the Dumfries Burghs. But the man who was mainly instrumental in creating an enlightened public opinion upon this subject was Edward Edwards, to whose memory a monument was recently erected over his grave at Niton, in the Isle of Wight, where he spent the last years of his life. Edwards became the first librarian of Manchester, the first library of importance instituted under Ewart's Act.

Libraries Supported by the Rates. The Act of 1850, like all the Library Acts which have been passed since, was an adoptive Act—that is, it gave a community power to adopt the Act by vote, and through its governing body to levy a rate of one halfpenny in the pound for the upkeep of the library. It was speedily seen that this rate was much too small for any effective purpose, and in 1855 an amending Act was passed permitting a rate of one penny in the pound to be levied. Despite the fact that this was sixty years ago, and that the work of public libraries has developed enormously in range and importance since, the limitation of the rate to one penny remains, and is the great stumbling-block to the further development and extension of these institutions. In the cases of about fifty-five of the large towns, powers of levying a rate up to twopence in the pound, or even more, have been obtained by the expensive process of special local Acts of Parliament.

About 708 towns and districts in the United Kingdom have adopted the Acts to date. Most towns of any size have had to supplement the service of the central library by means of branch libraries, and the number of library buildings in the great towns, such as Glasgow, Liverpool, and Manchester, is considerable. Altogether, it is likely that the number of public library buildings in the country approaches 1000. This includes rented premises as well as buildings specially built for the purpose. The latter have largely increased owing to the munificence of Mr. Andrew Carnegie. The total number of volumes in the public libraries of the United Kingdom in 1911 was 10,995,115, and the total number of volumes issued in the year ended March 31, 1911, 54,690,222. These figures, large as they are, give only a very partial measure of the work done. They leave out of consideration the enormous use made of the news and magazine rooms, and such "extension" activities as lectures. The total income of these libraries in the same year was £812,718, and the total expenditure was slightly over the income, amounting to £814,932.

Salaries. The conditions of service in municipal libraries are directly related to the size of the library or library system and the income. Libraries differ from most other departments of local government in that their income is a fixed quantity, and cannot be raised, however insufficient it may be to meet the needs. The number and remuneration of library staffs are governed by these factors. There are three public libraries with annual incomes of £10 or under, and there are more than one hundred libraries with incomes of £100 or under. In the best of these cases it is scarcely possible to employ more than one person, and he, or she, cannot be a trained librarian. At the other end of the scale we have huge library systems like those of Glasgow, with an annual income of about £37,726, and Manchester, with an annual income of about £35,078.

Leaving out of consideration the very small libraries, the staffs consist of a head librarian, a sub or deputy librarian, branch librarians, and senior and junior assistants. The salaries of head librarians, disregarding libraries of less than £500 a year income, range from £70 to £700. The latter figure is very rarely reached indeed, and there are very few municipal librarians receiving more than £500 a year. In some cases a house is provided in the library building. The salaries of sub-librarians vary from £40 to £300, and of branch librarians from £50 to £250. Senior assistants may receive anything from £35 to £170, and junior assistants from £13 to £60, or more. Women and girls are employed in many libraries, and their number is increasing. It was recently estimated that there were in all about 3500 library assistants in Great Britain, of whom 1500 were women. The figures of salaries given above apply to male assistants; in the case of female assistants they range lower. In a few libraries women are heads, at salaries ranging from £100 to £150, but these libraries are small, and it is not at all likely that the principal library positions will ever be open to women. This is the case in the United States, where women constitute the bulk of library staffs.

Hours. The number of hours worked by assistants depends to some extent on the size of the library and the number of the staff. The average is about 45 hours per week. Owing to the fact that most public libraries are open continuously from 8 or 9 o'clock in the morning till 10 at night, the staff must work in shifts, and evening duty is a necessary feature of library work. Most libraries close for one half-day, and it is usual for assistants to have an additional evening free. Vacations range from four or five weeks for heads, to two or three weeks for senior

assistants, and ten days or two weeks for juniors. In addition there are public holidays, when most libraries are closed, at any rate in the book departments.

Qualifications. The methods of appointment vary. The more important posts, if not filled by promotion, are advertised in the local or district papers, and generally also on the front page of the "Athenæum." Previous library experience and the possession of some certificates of the Library Association, or of the diploma issued by that body, are generally essential. Junior assistants are appointed from the locality, and in most cases are put through some sort of preliminary examination at the library. Any boy who wants such a position should write to the librarian in his town, or to some other librarian in the locality, and ask to be informed of any forthcoming vacancy, at the same time stating any special qualifications he may possess. Perhaps two of the best qualifications are the possession of some general information, such as may be obtained by any boy who reads the newspaper intelligently, and a knowledge of some of the great works of literature. The average boy of fourteen of today is so well supplied with books written specially for him that his knowledge of some of the great "grown-up" books is very small; the boys of an older generation, if they had the desire for reading at all, read far more widely, and gained much by so doing, even if, as happened many times, they did not altogether understand what they were reading.

It is, however, one of the commonest errors made in regard to library work to suppose that "bookishness" is the only qualification necessary. There is no department of the Local Government service which makes a greater demand upon the qualifications which make for success in business than does the public library. It is a fact not generally known that the outstanding characteristics of modern business organisation are due to the library. The card index, the loose-leaf ledger, various methods of filing, are all based on methods first worked out and applied by librarians; but, in addition to a love of books and a capacity for business, the true librarian must have an intelligence alert at every point, a large fund of miscellaneous information, and wide and catholic sympathies. As the public library is not only a recreative and educational institution, but is also an important form of social service, the librarian must also be imbued with the missionary instinct if he is to fulfil all the requirements of his office.

Training. The Library Association, which is the principal professional body, founded in 1877 and incorporated in 1898, organises or promotes lectures and classes in library economy, holds examinations, and issues certificates and a diploma. The examinations are limited strictly to librarianship in the technical sense, but a good general education is presupposed, and is essential for the efficient performance of the duties attached to any position in a public library above the grade of junior assistant. Examinations are held in the following six subjects:

1. Literary history.
2. Elements of practical bibliography.
3. Classification.
4. Cataloguing.
5. Library history, foundation, and equipment.
6. Library routine (practical library administration).

Certificates are issued for the examinations in each of these subjects, either for a simple pass, or a pass with merit, or with honours. Lectures are given every winter in London under the auspices of the Library Association, and are also held on various portions of the syllabus at Birmingham and Liverpool. For the benefit of students unable to attend lectures the Association organises correspondence classes. Lectures are open to anyone, and certificates granted, irrespective of work in a library. Students who possess the six certificates may enter for the diploma, but may be required in addition to undergo a further oral test. The student must also present a thesis showing original thought or research on some subject within the purview of the syllabus, previously approved by the Council of the Association. He must have worked for not less than twenty-four hours a week for at least three years as a member of the administrative staff of one or more libraries, and he must show that he possesses an elementary knowledge of Latin or Greek and one of the following languages—French, German, Italian, or Spanish. Further information with regard to the examinations, list of books recommended for study, and copies of the questions set may be seen in the "Library Association Year Book," published annually by the Association, price 1s. net.

The Work of a Junior Assistant. No description of the work carried on in a municipal library can apply to all libraries. In a very small library, where the staff is limited to a librarian and a single assistant, or even to a librarian only, it is clear that the division of work into junior and senior grades is inapplicable; the librarian himself must do everything. The larger the library, as a general rule, the more specialised the work. Moreover, the work of a progressive library, in touch with the most recent developments, will be much more varied and exacting than in the case of a library run on old-fashioned lines. One of the most striking differences of method, which may lead to variations of greater or lesser importance in the whole library organisation, is that between what is known as the "indicator" or closed-shelf system, and the "open-access" or free-shelf system. In the "indicator" system the shelves in the lending library are open only to the staff, and borrowers must apply for the books by number at a desk or counter; and in order to save the time of the staff it is usual to indicate whether books are "in" or "out" by means of columns of numbers in frames, the numbers being changed in colour, or underlined, or marked in some other way, according to the style of indicator in use. In the "open-access" system, borrowers have free entry to the books, which they choose themselves, and which are handed over to the staff counter either to be entered up against the borrower, or to be marked off if the book is being returned. For many years the "open-access" system was regarded by most librarians as a dangerous innovation, but extended experience has removed the prejudice against the system, and it is now being adopted in a great number of the recently opened libraries.

The principal duties of the junior assistant will be comprised in the work attached to the staff desk or counter, where the processes of entering the issue and return of books are carried on. In subscription libraries the most important record is kept under the name of the person borrowing, but in municipal libraries the principal, and generally the only, record is kept under the particular book borrowed. In the most common form of the indicator the particulars of the registered number of the borrower, and the date of issue, are written in a little book, attached

to a metal strip, containing the number corresponding with that of the book borrowed on the turned-up ends of the strip, which is inserted in a pigeon-hole in the frame. In open-access libraries, and in many indicator libraries where only a portion of the books (usually fiction) is represented by the indicator, cards are employed, and, by bringing the card representing the book and the borrower's ticket together in an envelope or pocket, the "charge," as it is technically termed, is made without any writing at all. These cards, thus temporarily "married," are inserted in trays behind the date of issue, and books which are overdue automatically show themselves.

The writing of notices to readers requesting the return of overdue books, and stating the amount of the fine to be paid, will be part of the work of the junior. In all these records great accuracy and care are required. The junior also in his contact with the public must learn to be helpful and polite, even under trying circumstances.

Another part of his work will be the replacing of returned books on the shelves. In an open access library it is usual for each junior to be responsible for a section of the shelves, and, as the books will be closely classified by subject, he will become acquainted at least with the titles of the works in his section, and so lay the foundation of a knowledge of bibliography. He will also have his part to play in the many processes through which books must pass between the time when they are received from the bookseller and the time when they are ready for the reader. This will include the examination of books for uncut pages, and the cutting of same—a simple process, but if carelessly performed a valuable book may be easily damaged.—the stamping of certain of the pages with the library mark of ownership, the pasting of the library labels inside the boards, and the tag or small label on the back of the book, which carries the marks by which the book is arranged on the shelves. Checking of newspapers and magazines is another branch of the junior's work. Other work is that common to all offices, such as stamping and posting letters, and similar office routine

The Work of a Senior Assistant. The term "senior assistant" may designate many different grades, but, as in a small library these may all be lumped into one, they are here described in bulk. A senior will usually have to put in a good deal of his time at the counter, and here he will supervise the work of the juniors. But in addition he will be engaged in most of the higher branches of librarianship. First, perhaps, in order of importance is *cataloguing*. As a junior he may have had some practice in copying the catalogue entries of books, and it may be said here that many persons never acquire the faculty of even copying anything accurately all their lives. Accuracy in small things as well as in great things is usually an acquired virtue, and it is the chief virtue of the library assistant. The senior, however, must be able not merely to copy what is given him, but also to learn to describe the book in proper bibliographical form.

Cataloguing. To write down the author of a book, the title, and certain other particulars seems a very easy task, but it is really an art in itself. It is not always easy to decide who is the author of a book, or under what part of the name, or under which name, an author should be entered, because authors very often write under pen-names, as well as under their own names; women writers who are married are another difficulty; noblemen may be entered under the titles they bear or under the family name, and there are dozens of problems of a similar kind which confront the cataloguer. Two of the fundamental principles of a properly compiled catalogue are that all books of an author shall be collected in one place, and that entries shall be made according to definite rules, and not in haphazard fashion. Otherwise the catalogue will be rendered largely useless as a key to the contents of the shelves. When the cataloguing is elaborate the number of such rules may be very great. There are many "codes," as they are termed, of rules, but the tendency now is towards uniformity, and particularly to the adoption of the "Cataloguing Rules: Author and Title Entries," compiled by committees of the American Library Association and of the Library Association, an English edition of which is published by the Library Association, price 2s. net. This code applies only to authors and titles; there are also rules published for subject catalogues. Rules for a printed catalogue must differ also to some extent from the rules for a manuscript catalogue. The latter are mainly to be found in the form of card catalogues, and a study of the card catalogue and the special problems connected with its compilation and guiding is in itself a large one. Nobody can learn to catalogue by reading a set of rules; one has to apply them to the actual books. In modern municipal library cataloguing, works are often annotated, and the subject of annotation has been specially treated. The ability to describe the idea and characteristics of a book tersely and truly calls not only for training but for a special quality of mind. This special quality of mind is perhaps still more necessary in the complementary art of *classifying*.

Decimal System of Classification. A quarter of a century ago hardly any libraries were closely classified; now close classification is common even in the smallest municipal libraries. Classification is a subject upon which a great deal of investigation and work has been done in recent years, especially in America, and one American system, known as the Decimal System, invented by Dr. Melvil Dewey, formerly librarian of the State Library of New York, is the most widely adopted. The principle of the system is that of indicating the subject of a book by a number, and it receives its name from the fact that just as the position of a figure in relation to other figures determines its order, whether in the units, in the tens, hundreds, and so on, so the position of the figure in the Dewey class-mark indicates its position in the order of the headings of the tables of subjects, whether class, division, or section; and the decimal analogy is followed by using the point to indicate the minute sub-sections of the scheme. Thus books of Self-Education and Culture are 374, and this number analysed breaks up into class 300, Sociology; division 70, Education; section 4, Self-education; and while 374 would mark all general books on the subject, books on special aspects of it would be indicated by a number beyond the decimal point. Thus 374·4 would be 374 as above, and ·4 would mark Correspondence Teaching. It will be seen that new headings may be inserted at any point by simply adding another figure on the right of any existing mark. The classification can also be carried just as far as convenient, and the number of books on a subject and the circumstances of the library will determine the degree of minuteness of the classification. Even small libraries will employ from 1000 to 1500 headings, but large libraries will use many more. The library assistant cannot know all these headings without reference to the

tables, but he must understand the proper use of the tables, and must be able from inspection of the book to give it its correct class-mark. It is impossible in the space allotted, nor would it be of much practical service, to enter further into this subject, or to notice other rival schemes which have been prepared. The same general principles govern all modern schemes.

Binding. It is impossible to leave even this cursory sketch of the work of the senior assistant without a reference to the department of binding. The binding and rebinding of books is naturally a large item in the municipal library, and the senior must know the best leathers and cloths to use in relation to the particular book to be rebound, and must also understand the various binding records, be able to draw up the necessary instructions, detail the lettering to go on the back, and finally check the binding on return.

The Work of a Chief Librarian. Little can be said in the space available of the work of a librarian. He is the link between the staff and the governing authority, and it is the business of the librarian to be responsible for the carrying out of the committee's instructions. As a general rule, committees confine themselves in the main to questions of policy and finance, and leave to the librarian the practical details of administration. Apart from the supervision of the staff and building or buildings, one of his most important duties is concerned with the selection of the books which shall be bought. The librarian usually submits a list of suggested purchases to a Books Sub-committee, and books are only ordered when their approval is obtained. The money available for new books in the majority of cases is inadequate, and the task of selection is naturally rendered more difficult because of this. The basis of the librarian's selection will be reviews in the various literary and scientific papers, suggestions from readers and experts, personal examination, a knowledge of the books already in the library, and of the special circumstances of his locality. Experience, judgment, and broad-mindedness are necessary if the funds of the library are to be expended to the very best advantage.

In the early days of the public library the emphasis, both in buying and in home circulation, was on fiction, but in recent years the percentage of fiction read has been gradually dropping, and in some towns is now surprisingly low. This is partly due to the extending use of libraries for educational purposes, and partly to the greater proportion of money spent on non-fictional literature. The average proportion of the book fund—excluding the reference department—spent on fiction may be taken as about one-third. Only the best novels are bought, the circulation of fiction of third and fourth rate value being rightly left to the commercial circulating libraries.

The general aim of committees is to form as representative a selection of books as is possible within the means at their disposal.

In regard to subjects which divide themselves sharply into *pro* and *con* divisions, and relate to the hotly debated political and social topics of the day, it is the duty of the public library to provide the best and most authoritative expositions on every side of the question. In certain directions, depending chiefly on local circumstances, every library but the very smallest specialises, generally on the principal trade or industry of the district, and on the town or county history.

There are always collections of books for children, and in many places these are shelved in children's reading-rooms. The number and variety of books written for children is one of the distinguishing features of modern publishing; and owing to their scanty and unsatisfactory treatment in the literary papers, this is one of the most difficult departments of selection, and at the same time one of the most important. A grown-up reader is either immune from rubbish or his taste for it is beyond cure; but the taste of the young reader is as yet unformed, and he can only be taught to like what is good by having only what is good put before him.

The selection of books for a reference library raises problems somewhat different from that of books intended to be taken and read at home. The amount of money available will still more rigorously dictate the lines of selection. If this is small, a representative reference library is impossible, and the attempt at it should not be made. The books bought should be those which give the most varied information in the most compact and convenient form—namely, encyclopædias, dictionaries, and the like.

There are many departments of library management not even mentioned in the foregoing paragraphs, but enough has been said to give the reader a general idea of the kind of work done in libraries. As the details of salaries given earlier on in this article will have clearly shown, the profession of librarianship is a poorly paid one; it is, however, gradually improving, and for one who is drawn to the work it has many compensations.

Organisation of the Profession. The Library Association, whose offices are at Caxton Hall, Westminster, S.W., is, as already stated, the principal professional body. Membership is of three kinds or orders. Under the regulations which now apply, Fellows are persons who possess the diploma of the Association; and Members are persons who possess any four certificates of the Association, and who have had three years' approved library experience. Associate Members are either librarians who are not qualified as Fellows or Members, or persons who are not librarians but are members of library committees or boards, or interested in libraries or in bibliography. The Association is in no sense confined to municipal librarians, but is representative of every class of library. Fellows and Members pay an entrance fee of one guinea, and an annual subscription of one guinea; Associate Members pay an annual subscription of one guinea and no entrance fee. All members receive free "The Library Association Record, a Monthly Magazine of Librarianship and Bibliography," published by the Library Association, price 2s. net per number.

Library assistants have their own association, the Library Assistants' Association, whose membership is confined entirely to assistants in libraries, or chief librarians who have been hitherto members or associates of the Association. Membership is of three grades: Fellows are chief librarians, as aforesaid. Members are persons engaged in library administration other than chief librarians. Associates are persons engaged in library administration other than librarians, whose salary does not exceed £55 per annum. The annual subscriptions are 7s. 6d., 5s., and 2s. 6d. respectively. "The Library Assistant," published monthly (annual subscription 4s.), is the official journal of the Association. The secretary is Mr. W. Benson Thorne, Public Library, Brunswick Road, Bromley, Poplar, E.

L. STANLEY JAST

Taxidermists and Naturalists. Tobacconists. Toy Merchants. Undertakers.

ENCYCLOPAEDIA OF SHOPS—10

TAXIDERMISTS AND NATURALISTS

A LARGE town, preferably a port, is the best place for the business of a naturalist and taxidermist; and for the sale of smaller specimens, such as mounted butterflies, moths, and beetles, proximity to a large college is an advantage. The business is usually started in quite a small way, often in a private house, and, except in specially favourable centres, there is very little room for a business of any pretentious size. This being so, nothing can be said as to the capital necessary to begin as a taxidermist. Everything in this business depends upon personal skill and effort. The prices, too, at which specimens are sold vary tremendously, and no standard can be followed. The cost—time of taxidermist, materials used, and proportion of overhead charges—must be worked out, and a reasonable margin of profit added. The all-important qualification for success is skill in preparing specimens.

In attempting the practice of taxidermy, the best subject for a beginner to experiment on is a bird—not too small or delicate—such as the common starling, the feathers of which are not difficult to handle, and the skin fairly tough.

The tools [1] necessary are a sharp-pointed knife—a penknife will do; a pair of strong, pointed scissors; a sharp-pointed awl or pricker; a pair of side-cutting pliers for cutting wire; a pair of tweezers for arranging the feathers; a file and a needle. We shall also require some cotton-wool and wire; some pins and glass eyes; tow, wood-wool shavings, similar to those used for packing; some strong thread and soft cotton; powdered alum, arsenical soap, fine sawdust, and a little plaster of Paris.

Preparing the Bird. The first operation is to put a thread through the nostrils of the bird, making a knot, and leaving a loop as long as the neck and body of the bird. The loop will be of great assistance in returning the head when the body is skinned. Plug the nostrils, throat, and any shot-holes with wool. If the body is very moist, use a little sawdust and plaster of Paris to absorb the blood. Break the wing-bones (the humerus) close to the body. Make an incision in the middle of the breast [2], first blowing the feathers apart, and continue the cut to the vent. Care must be taken not to cut too deeply in the abdomen, or the intestines will protrude, and give great trouble by making the feathers dirty; sawdust and plaster should be applied to prevent this. The skin should be pressed back with the side of the knife. No further cutting will be necessary until the tail and the legs are undertaken, when the scissors should be used to snip the tail-bone. The legs should be pushed up, and the first joint exposed must be cut with the knife.

Remove the flesh from the leg down to where the feathers end, return the leg-bones to the skin, and proceed to press the skin away from the back. Cut through the wings where broken, and turn the skin inside out down to the head, holding the body between finger and thumb. Great care must be taken not to split the skin in getting it over the head. The ears will first be met and cut through; then the eyes, which require still more care. Skin down to the bill [3]. Cut through the base of skull, and remove the neck. The brain, tongue, and eyes should now be removed, and the sawdust and plaster brushed off. Apply alum to the skin if very moist or not quite fresh; anoint all bones and the inside of the skin carefully with the arsenical soap, and place a ball of wool in the orbit of each eye.

Variations of Method. Certain birds, such as ducks and divers, have very large heads and long, narrow necks. It will be found quite impossible, in skinning them, to get the skin of the neck over the large head.

In this case, skin as much of the neck as possible; then cut it off, return the skin to its natural state, and smooth the feathers.

Now proceed to skin the head by making an incision starting at the ear, and continuing the cut down the neck just far enough to have the opening large enough to press the skull through. After removing all the flesh, the eyes, and the contents of the brain-box, anoint all parts with arsenical soap, then place the pads of wool in each eye, and return the skull to the skin, and carefully sew up the opening made. If care be taken, no sign of the seam will be noticed when the bird is finished.

In all birds above the size of finches the wings will require skinning. In the smaller birds the amount of flesh is so small that it dries in a very short time.

The opening is made on the under side. Place the wing flat on the table, fix it down by placing a weight on the quill feathers, then extend the wing to its fullest. With a sharp-pointed knife make an incision, beginning at the last joint of the wing; make the cut between the rows of feathers, cutting towards the body, taking care not to cut any of the feathers. The flesh can be removed in strips if the sinew is cut at the end of the joint; care must be taken not to cut the skin on the outside of the wing, or some feathers will fall out. After anointing the bone and skin with arsenical soap, a little chopped tow should be used to replace the flesh, and then the skin neatly stitched together, being careful not to sew any of the feathers down with the thread.

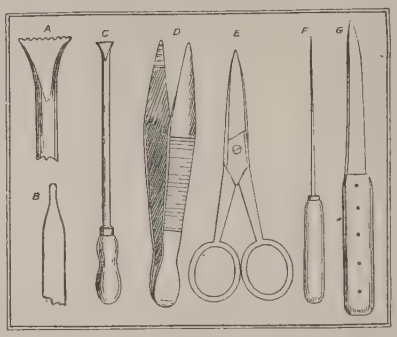
In skinning birds with white breasts, such as gulls, divers, and some kinds of ducks, it is better to make the opening on one side, as the purity of the breast will then be preserved. Make an incision under the wing, and continue down to the vent, then proceed as previously described. The skins of most water-birds are always very greasy, the fat clings to the inside of the skin, and the quills of the feathers projecting into it render it a troublesome task to get it off. A knife must not be used on account of the quills, which if cut will cause the feathers to drop out. Use an old rasp, rub the skin gently; the motion should be from the neck of the bird to its tail. After a time the fat will begin to collect on the rasp. Now sprinkle some sawdust on the skin, and continue the rubbing; the sawdust

will gradually absorb the grease. Throw away the greasy sawdust, and add clean until the skin is free from fat.

It is necessary to remove all fat from the skins, as, if left on, it will not allow the preservatives to act, and the skins will become rotten and brittle. Benzoline will clean the edges where the feathers may have become soiled.

Stuffing. Now lay the skin on the table, and return the skull to its proper position; the loop of thread in the nostrils will assist this operation. Coax the skin with finger and thumb over the skull, and the whole skin will, with a little shaking, return to its natural position. Smooth the feathers of the head the right way, and work the body-feathers downwards into position. Now make an egg-shaped body the size of the one taken out, using the wood-wool for this, pressing it together tightly, as the leg wires must depend on it for fixing firmly. Cut a wire twice the length of the neck and body, and point it at both ends. Drive the wire through the body, make a loop, return it, and then clinch it.

Wind a little tow round the wire to form the neck, being careful not to make it longer than the one taken out; and drive the wire through the centre of the skull and work the skin down over the body. Cut two wires three times as long as the legs, point at one end, and insert one underneath each foot, working it up the back of the leg; a little tow must be wound round the wire and bone to make up the flesh removed from the thigh-bone. The wire is now driven through the body, out under the opposite wing, turned, and pulled back into the body. A slit must be cut in the skin to allow the loop to pass and so leave the skin free. Insert a little pad of tow in the base of the tail, and sew up the skin, taking care not to sew down any feathers. The legs should be bent into their natural positions.



1. TAXIDERMIST'S TOOLS

a. End of stuffing iron *b*. Section of stuffing iron *c*. Complete stuffing iron *d*. Tweezers *e*. Scissors *f*. Pricker *g*. Skinning knife

When the operator has reached this stage, he will be able to judge if he has made the body the right size. The skin should have met easily over the hard, oval body, and usually a little additional stuffing is required, which can be easily inserted through the small slits which have been made under the wings to allow the wire loops fixing the legs to be pulled into the body. Always use chopped tow for the additional stuffing, using a small stuffing-iron to work it in through the slit into position. On no account should cotton-wool be used, as this material felts into a hard lump, and is not easily moved about under the skin; its worst feature is that it is difficult to penetrate when in subsequent operations the wires and pins for fixing the wings are inserted.

Mounting. The bird has now to be fixed on a twig or a perch. Two holes are bored through the perch to take the leg wires, and the wires are twisted firmly to the perch. The tail must now be adjusted, one—and sometimes two—pointed wires being used to fix it in position. The wings require two wires each, one through the shoulders, the other near the roots of the primaries or quill feathers. Fix both wings the same height, or the bird will appear lopsided when completed.

The throat may be filled out from the mouth with tow, finely chopped with scissors, and the cheeks filled from the eye. The eyes are then inserted, and the tail expanded to the required width between two slips of cardboard.

The final binding with cotton is next, a long pin being inserted in the back, and one or two in the breast, keeping to the centre line of the body. The pins, with the four long wires, and the wire protruding from the bird, are utilised in winding the cotton round the bird to compress the feathers gently into place while the bird is drying [4]. The novice must not expect his first bird to be a great success, or perhaps his sixth or twelfth, for, simple as the operation may seem, it requires practice to get the natural shape and pose.

Foreign Birds. For brilliance of plumage the palm must be awarded to the foreign birds. They are usually brought to this country as dried skins, and before they can be mounted require to be relaxed by moisture. This may be accomplished with ease. Wrap each bird in paper; prepare a box containing damp sawdust, or, as an alternative, damp sand; cover each bird with the damp material, and after forty-eight hours examine to find if the skins have absorbed sufficient moisture to make them pliable. A good test is to try if the toes will move easily; if this is so, then the seam in the abdomen may be opened, and the material with which the skin has been filled may be carefully removed; a pair of tweezers are very useful for this.

In removing the stuffing great care is required in order to prevent the skin tearing; in foreign birds this is very brittle until fully relaxed. A short piece of stick, and sometimes a wire, will be found inserted in the neck; in removing this, great care is required, as it may come away with a jerk, which might easily tear off the head. When empty, the skin should be filled with damp sand or sawdust, and replaced in the relaxing box, in order to allow the skin to absorb enough moisture to enable it to be handled with safety; twenty-four hours should be sufficient for this. The skin should then be turned inside out and scraped, especially the roots of the feathers, adding a little moisture in order to make the skin quite pliable. This is a most important point, and one which must not be omitted; the fact must be realised that the skin has become shrunken in drying, and before one can help to make it a lifelike specimen it must be well stretched and softened. Arsenical soap may also be worked into the skin; this will be of great assistance in softening it.

To stuff and mount foreign birds, proceed as described for fresh skins, but the difficulties to be encountered are a more stubborn skin, and one which has been dried in an unnatural shape, requiring more than ordinary patience to overcome.

Animal Stuffing. Small animals up to the size of a rabbit will require the same tools and materials as those required for mounting small birds. Before skinning, an outline of the animal should be made by laying it on a sheet of brown-paper as nearly as possible in the position in which

it is intended to mount it, and its shape marked with a long pencil or crayon, the size of the body being marked on this sketched outline.

Always skin an animal down to the toes. The tails in small animals can be drawn without cutting them open. The lips must be split, and moist clay inserted to give them fulness. The ears must be skinned, and clay used to replace any flesh taken away; sheet zinc, cut to the proper shape, is used to stiffen and keep them in position. Always keep the leg bones on the skin, as they are invaluable in shaping and posing the animal.

The hard, egg-shaped body used in bird-stuffing is not used for stuffing animals. The head and body wire is twisted in tightly with the fore legs first, then the hind legs. The length of wire used must allow for fixing the animal upon the stand.

The neck and body are gradually filled with chopped tow, wood-wool, and sometimes with hay, keeping the shape and ultimate position in view. Never use tow without chopping it up small, or it will form an immovable ball inside the skin, and show an ugly lump; cotton-wool, too, should be avoided for the same reason. Soft pipeclay is very valuable in the head, feet, and those parts where such details as muscle must be shown. Always use annealed iron wire, thick enough to give stability, and bear in mind that it is easier to add a little stuffing than it is to get it out.

2. BIRD-STUFFING: THE FIRST INCISION
a. Thread loop tying up beak

3. BIRD-STUFFING: SKIN TURNED INSIDE OUT
a. Point to cut head from neck
b. Thread loop to assist in returning the skin

The hair must be cleaned and brushed and combed in its natural direction while the specimen is wet; blood and grease must be washed out before stuffing. Fat left on the inside of the skin prevents any preservative acting properly, and will cause the skin to rot. It is better to allow the skin to remain a few hours for the alum to act on it before applying the arsenical soap. The action of alum is astringent, shrinking the skin and so fixing the hair firmly by the roots; it will also extract the surplus moisture from the skin, but any crystals remaining undissolved are better brushed off before applying the arsenical soap. The eyes, ears, lips, and toes require special attention, to see that the alum is worked in well. If the skin cannot be stuffed immediately, do not let it remain folded on itself; place a little hay or tow inside it to prevent the inner surfaces touching. If this is not done, the skin will sweat, decompose, and the hair will fall off at the slightest touch. The leg bones must also be wound round with tow.

Larger Animals. The larger animals require a different treatment; the legs in animals the size of deer and larger must be opened right down the inner side, so that the seam is least noticed when mounted. The irons for the legs will require to be tapped, and two nuts fitted to each leg, to give the support to carry the weight when fixed up. The irons must be bent to the proper curves and angles, which the paper outline will give. A board, about 2 in. thick, must be cut to the shape and size of the body. The leg irons are very firmly fixed to the board by iron staples, as also is the iron for the head and tail. The head iron is brought through the skull by passing it through the nostrils, and is cut to its proper length when the head is finished [5].

The bulk of the body is made up by fixing dry straw to the body-board. It must be tied securely round the board with string, shaped as nearly as possible to the pattern and measurements, and made a little under the proper size [6]. The skin may now be tried on, and if the edges meet comfortably, and the legs are the right length, the skin may be sewn up. Begin sewing at the neck and work downwards.

The dried skins of the larger animals are very stubborn, and require to be pared down with a spokeshave, the skin being laid on a short length of a scaffold pole. A knife must be used for the more important parts, such as the ears, the eyes, and the nose; and the lips, if they cannot be split, must have linen sewn round the edges to form the pocket for filling with clay.

Fish Stuffing. The stuffing of fishes is one of the most difficult branches of taxidermy, and it will try the patience and skill of the novice to the utmost.

The fresh-water perch is a good species to experiment with. Choose the best side for the show side, and mark its outline on a sheet of paper as a guide. Make a cut on the other side with a strong pair of scissors, down the middle of the body from the centre of the gill-cover to the root of the tail. Use a knife to free the skin from the flesh, and cut from tail to head. The skin of a scaly fish must not be turned, as in birds and animals, or the scales will be disturbed. The root of the tail and fins must be cut with the scissors inside the skin. See that the points of the scissors do not cut the skin, or a few scales will drop out. The gills and all the bones of the head must be cut away with the scissors. When the skin is ready, it must be soaked in water to remove any blood and slime that may adhere to it. All loose scales should be saved, as they will perhaps be wanted for repairing the skin. There are several methods of stuffing fish, and one of the simplest of them can be used for fish up to the weight of 5 lb.

Damp Sand Method. Take fine yellow sea-sand, damp it so that it is just tenacious enough to retain a shape when grasped by the handful. After using arsenical soap on the skin (alum should not be used for fish), sew up the skin a few inches at the head, and also at the tail. Place a loose ball of tow in the mouth to keep the sand from coming out, and fill the skin with the wet sand, pressing it tight and modelling the shape as the filling proceeds. Finish the filling in the middle of the body and sew it up. The fish must now be turned over on a board, a little longer and wider than itself, on which it is to lie and dry. Pat the head into shape, and work the body downwards to its proper curve. Fish skins always tend to become longer, and this must be prevented, or the result will be a failure. The fins and tail must be extended and fixed between two pieces of cardboard, pins being used for fixing them. The fins and tail must not be allowed to dry during stuffing, as in this state they are very brittle, and cannot be extended properly.

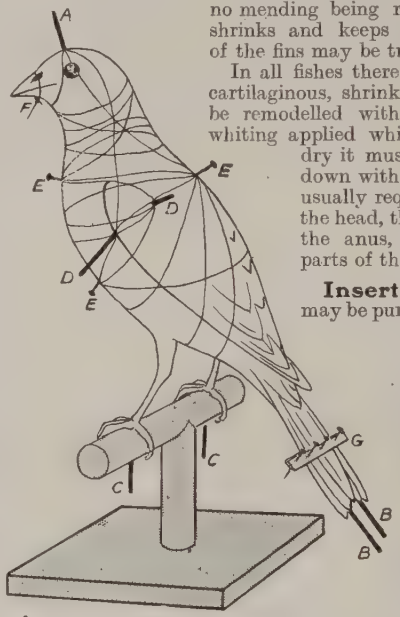
When the fish is properly fixed, a thin coat of gelatine, melted in warm water, will keep the scales in position. The fish must now be placed on a warm shelf to dry slowly, and examined occasionally to see that it is drying smoothly.

When the fish is dry, remove the sand by opening the seam and gently tapping the body. It is then

filled with tow, wood-wool, etc., and the seam glued together and covered by a strip of linen. A small wooden block to which are fixed two wires is also glued on the seam for fixing up the fish in a case.

The finishing and colouring of fish require much practice, and it is easy to overdo the colour. Use, whenever possible, transparent oil colours and a clear "crystal" varnish. The belly colour is the most important point to get right. It is usually white, and is shaded gradually to the colour of the sides. The eyes must be of the same size as in nature; the orbit of the dried fish is always larger than in nature, through shrinkage, so it must be filled up to its proper size with a composition described later.

Use of Plaster of Paris Mould. Fishes, especially those with a smooth skin, may be stuffed with the aid of a plaster of Paris mould, and this is undoubtedly the method by which the correct shape can be obtained. Place the fish on its side on a board slightly larger than the specimen, choosing the side least damaged for the show side. Arrange the tail and fins in a natural way on pieces of cardboard supported by wet clay. Bank clay around the fish so that it presents the appearance of a half relief; then fit strips of wood round, forming a rough box to keep the liquid plaster within bounds, making it water-tight with wet clay. When mixing the plaster of Paris do not add the water to the dry plaster; this is likely to cause hard lumps to form. Have just sufficient water in a bowl, and sift the plaster gradually into it; when sufficient plaster has been dropped in an island will be formed; this is the signal to begin stirring. When thoroughly mixed, pour it slowly on to the prepared fish, covering it with a layer about one inch thick for small fish, but thicker for a large mould. Give the bare board a few sharp taps; this will remove any air bubbles in the liquid plaster. In about one hour the plaster will be set and the fish may be removed. The result should be a perfect mould of the specimen.



4. STUFFED BIRD READY FOR DRYING
a. Head, neck and body wire *b.* Tail wires *c.* Leg wires *d.* Wing wires *e.* Pins to keep cotton in position *f.* Thread to fasten beak. *g.* Cardboard slips to hold tail feathers

When the fish has been skinned and cleaned ready for stuffing, the skin should be laid in the mould, which has been previously oiled. Fix the fins and tail in position with pins; now prepare a piece of wood for the body, shaping it to reach the root of the tail. Wood-wool may be tied on to the body-wood to make up the shape to within half an inch of the original. Mix a small quantity of plaster, and pour it on the skin in the mould, then place the wooden body in and press it down; the plaster will then fill out the skin to take the shape of the mould. A suitable weight may be used to keep the body-wood down while the plaster is setting. The skin can be drawn together in the next operation, and the filling may be pressed in to make the reverse side correspond in thickness and shape with the front or show side.

Treatment of Fins and Tail. The fish should now be fixed on a board with two screws driven through from the back of the board into the wood inside the fish.

The fins and tail can now be expanded. Cut the cardboard slightly larger than the fin, then paste the under side; now fix tissue paper on by turning it over the edges of the cardboard. Be careful to keep the upper side free from paste. The fins and tail may now be expanded and fixed with paste on the tissue paper; a few pins will help to keep the more obstinate rays in position.

The advantages of this method is that the operator can see all the fins after fixing, and can therefore judge the effect better than if they are covered in by cardboard. Also, when the fins are dry, a knife can be passed between the tissue paper and the cardboard leaving the fins free and perfect, no mending being required. In drying, the paper shrinks and keeps the fin quite flat. The edges of the fins may be trimmed with a pair of scissors.

In all fishes there are certain parts which, being cartilaginous, shrink very much; these parts must be remodelled with a composition of glue and whiting applied while warm; after this is quite dry it must be made smooth by rubbing down with glass-paper. The parts which usually require making up are the top of the head, the mouth, the fleshy under jaw, the anus, and, in some fishes, certain parts of the gill-covers.

Insertion of Eyes. The eyes may be purchased from the manufacturers, but require to be coloured for each individual. The pupil is always round in these ready-made eyes, but in very few fishes is this so in nature; therefore the pupil must be shaped with a very fine brush, using blue-black for the purpose. Some fishes have pupils slightly pear-shaped, others quite oval. When the paint is quite dry, proceed to tint the glass with the required colour, using a fine brush, with a stippling motion, and again place aside to dry.

Before the eye is placed in the fish, fill the orbit with cotton-wool, on the top of which is laid a small piece of silver leaf; place the eye on this, and press it into position, then fix all with the best composition of glue and whiting. The backing of silver leaf will give a more transparent effect than silver paint.

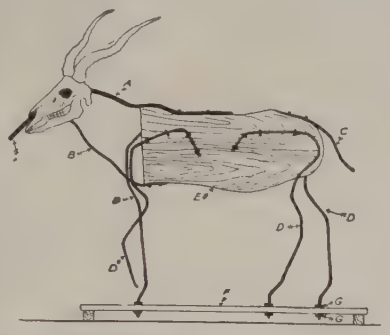
Some very natural fishes' eyes may be made by using the convex glasses sold by jewellers for fitting into lockets; these may be coloured on the concave side as described, and usually result in a more natural appearance than the thicker glass eyes.

Colouring the Fish. Undoubtedly the most difficult task is the colouring of a stuffed fish. If this is not done properly, all the previous good work is nullified. The knowledge of the blending of the various colours is essential. In most fishes the skin and scales, when dry, lose all the brilliant colouring and the silvery sheen. To replace this, the fish must be coated with aluminium leaf (sold in books similar to gold leaf). Do not use silver paint, as even the best kinds only give a dull, leaden effect, and will not keep bright. Give the

fish an even coat of gold size, omitting the fins; allow the size fifteen minutes to dry partially—when it is ready it will feel tacky to the finger.

Open the book of aluminium leaf and apply the lower portion of a leaf, bending the book quickly and firmly over the surface to be covered. The aluminium will readily cling to the tacky surface. In applying the next leaf, cause it to overlap the first at its edge, and so on, until all the fish is covered, including the abdomen; then with a pad of cotton-wool gently dab all the coated surface to ensure a perfect contact, and so induce the leaf to reach various hollows.

The work must now be put aside for a few hours until the gold size is quite dry, when the surplus leaf should be gently brushed away with a camel-hair brush. If any portion should show patches which are not covered with leaf, these must be coated with fresh gold size, and a portion of leaf applied. The joints of the leaves should not show if proper contact has been made and the leaf has been applied without crumpling it.



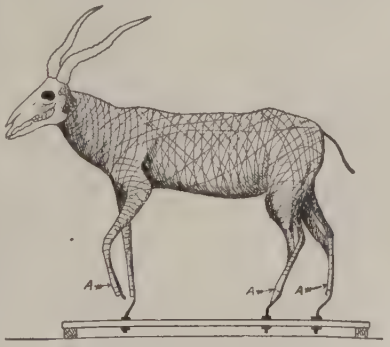
5. ERECTION FRAME FOR AN ANTELOPE
a. Head iron *b*. Neck iron *c*. Tail iron *d*. Leg irons *e*. Body-wood *f*. Temporary stand *g*. Leg iron nuts

Application of the Colours. Whenever it is possible, a live fish should be used to copy, as in all fishes the colours fade immediately after death. If the fish is one which is difficult to obtain, a water-colour sketch should be made of it before skinning; this would be a little guide to colour from, especially for the distinctive marking, such as spots and bars on fins.

Begin by colouring the belly with flake white, blending upwards; all the fins should be whitened. The fine-pointed sable-hair brush should be used to outline the scales. If the fish is a silvery one, use Payne's-grey, but in fishes whose prevailing colour is pink or brown, rose-madder or Vandyke-brown should be used respectively. When the scales are all marked, allow the paint to dry. Some oil colours are very slow in drying. Gamboge, black, Vandyke-brown, Prussian blue, crimson lake, and rose-madder all require a little terebene added to hasten the drying.

In applying the colours, begin with the lighter shades; for instance, if the fish is to be brown, apply first thin gamboge, then blend in Vandyke-brown, starting near the dorsal fin. Then, if a tinge of green is required, use Prussian-blue. The secret of success is to apply the colours very thin, bearing in mind that it is easy to darken them if necessary. Use a large brush, and apply the paint with a stippling motion to prevent streaky brush-marks showing.

When the paint is quite dry, give the whole a coat of crystal varnish; this will bring up the colours and give a transparent effect. When mounting fish in cases, etc., the best colour for the background is pale green, streaked horizontally with light blue to represent water. An artistic effect can be produced if rushes and weeds are painted on, and a few light strokes of the brush containing green passed over them horizontally to give a watery effect.



6. MANNIKIN READY FOR SKIN
a. Artificial leg-bones of wood

Preserving Fishes and Reptiles Entire. The use of formalin (formaldehyde) is now very popular for preserving fishes and reptiles. It has its disadvantages, however. If the solution is too strong, it shrinks the tissues very suddenly and distorts the specimen, which cannot afterwards be relaxed. A 10 per cent. solution is quite strong enough for general purposes. This proportion is not poisonous (a great advantage); and if the skins of fishes are soaked in it for a few hours before stuffing them, the scales will be firmer, and flies and other insects will be repelled. It is largely used to preserve small fishes for use as spinning baits for anglers. The specimens should be laid flat on a dish and covered with the solution. When it has acted enough to stiffen them, they may be placed in large jars with fresh solution, and sealed.

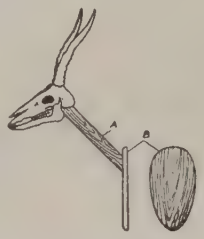
Plaster Casts of Fishes. A cast of a fish is always a more faithful reproduction than a stuffed specimen, as there is no shrinkage to spoil the effect, and consequently very little making up is required. Follow the previous instructions given for making the mould, but special attention will be required to ensure that the cast, when made, will be easily removed from the mould without breaking. Cut away and make smooth projecting parts of the mould which are not included in the shape of the fish, and fill in with clay any holes which are dangerous and likely to cause the cast to cling to the mould. Then give the inside of the mould several coats of French polish—this will create a hard working surface, and prevent the oil soaking into the mould. Linseed oil is very good to use on the mould.

Prepare a wooden body as described for stuffed fishes, but in addition cut strips of coarse canvas to place in the tail and fins to strengthen the plaster. When everything is ready, mix the plaster, and pour in sufficient to give a coat of about half an inch to every part of the mould. Then press down the wooden body; now place the strips of canvas in the fins and tail, being careful that a good thickness of plaster is available.

The canvas and the body should be quite covered in with the plaster, and the whole left to set. Then the mould may be removed by gently tapping it. While the plaster is still wet, the cast may be trimmed with a sharp knife. The fins should be bevelled to give an appearance of thinness from the front view, but the finer details had better be left until the plaster is quite dry and firm. Give the cast a coating of thin soap, then a coat of French polish, before proceeding to colour it; this is necessary, as

plaster is so absorbent. Silver and colour it as described for stuffed fishes.

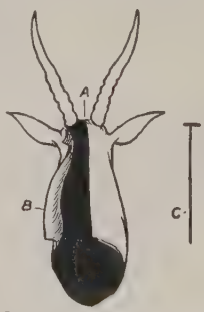
Mounting Animal Heads. If the animal has horns, it must be skinned by having a cut made up the back of the neck until it is level with the base of the horns, when a T-shaped cut must be made up to each horn, and continued round the bases to free the skin, so that the skull comes away entirely from the skin [8]. Remove the flesh from the skull, which must be boiled until thoroughly clean, and when it is dried it will be ready to mount inside the skin. The skin is rubbed, first with alum and then with arsenical soap, and the ears fitted with zinc and clay.



7. WOODWORK FOR GAZELLE HEAD
a. Quartering fixed in skull *b*. Back-board

Heads are fitted up differently from those of animals stuffed entire. Thick wood takes the place of iron for the support, and a piece of quartering, longer than the neck, is fixed in the skull, and several long screws driven at right angles through the bone into the wood. Cut a board not less than 1 in. thick, nearly the shape of an elongated egg, and trim off all sharp edges smoothly. This is called the back-board, and must correspond with the size of a cross-section of the neck at its extremity [7]. The quartering, having been fixed in the skull, must be cut to the length of the neck. The neck should be as long as the skin will permit; short necks look very bad, and an animal stuffed with a long neck can be made to look much more lifelike.

The skull, as at present fixed, should be hung on a wall, to find if the quartering is cut to the proper angle, so that the neck may be given a graceful curve. If there are horns in the specimen, the points can be brought to within 2 in. of the wall with safety. Horns do not always grow evenly, but it is possible to rectify this slightly while fixing up the skull. When everything is satisfactory, wood-wool is bound round the quartering to the shape of the neck [9], the skin is fitted on, and sewn up. Begin the sewing at the horns, and work down to the back-board; any stuffing which the neck requires must be inserted before the skin is fixed to the back-board. Three-quarter-inch French nails are the best to use for fixing the skin, as in drying the skin strains very much, and would pull shorter nails out. The cheeks are stuffed from the mouth and eyes, and the head finished as in entire specimens, plenty of clay being used in modelling the eyes, nose, and mouth. The glass eyes should be put in after the skin has dried, on account of the shrinkage during drying.



8. SKINNING A HEAD
a. Cross cut *b*. Skin partly removed *c*. Shape of cut

The shrinking of the skin is the bane of the taxidermist. The chief causes of shrinking are insufficient paring down of the skin, using clay too wet, stuffing the specimens too loosely, and not fixing and sewing up the skin tightly.

Before colouring the eyes, nose, and mouth, the specimen must be cleaned and beaten thoroughly. White French polish and methylated spirit in equal parts, and dry powder colours, are the best materials for colouring. Use stiff hog-hair brushes to work the colour in, and do not forget that the colour will, when dry, be half as light again when the spirit evaporates, which it does quickly. A little varnish will be required on portions which in nature are wet, such as eyelids, nostrils, open mouths, and lips. The horns are cleaned with soda-water, and rubbed with linseed oil and turpentine, to darken them.

Finishing and Casing. Cases should not be cramped, plenty of room being allowed for rock-work, glasses, and fittings, in order that they may be displayed in a natural way.

The case had best be made by a cabinetmaker; the wood used mostly is deal. Insist on having the best material and workmanship, as a faulty case will spoil everything. Panel backs to all cases are best, as splits in the wood are thus avoided. The back is lined with calico, carefully stretched and fixed with glue and tacks. When this is dry, paste white lining paper evenly over the calico. All the wood-work which is inside, except the bottom, must be coated with size mixed with powdered red lead; if this is not used the resinous matter and knots of the wood will show through the paper and make ugly spots. The inside of the case should be coloured with water colours, and a landscape may be represented.

Rockwork. Rockwork is made with brown-paper supported with wood, and in large work the basis is canvas, covered with paper wetted with warm water, and laid on evenly with glue. Considerable taste and practice are required to get the appropriate angles and curves to imitate different forms of rock.

When the glue is dry, the basis is quite stiff enough. Melt some size by adding one-fourth its bulk of water; add slowly to it crushed whiting until it has the consistency of gruel; apply this *hot* to the prepared basis. Have some dry sand, yellow or silver, according to the rock you wish to represent, heated to a temperature comfortable to handle, and throw it forcibly on the hot composition. When cold, gently knock the rock-work, and all sand which has not adhered will fall off. Colours ground in oil will do for colouring the rock-work. Do not overdo the colours—follow Nature in every way.

9. GAZELLE HEAD
Ready for skin to be fitted on

Grasses, ferns, rushes, and boughs must be thoroughly dry before using, and may be coloured with oil colours to which a very little varnish is added. Avoid stiffness; everything should look as if it were growing. This portion of the work is one which requires and deserves as much time as possible to be devoted to it.

The glass should be cut to fit the case exactly, and fixed by strips of wet paper of the same colour as the case. Black is by far the best colour to show up most subjects. The paper is applied with very smooth paste made from ordinary flour. As the paper shrinks in drying, it gives a stronger fixing.

Cleaning Skins. Fresh blood can be removed easily by washing the blood patch with warm water, of a temperature not above blood heat, in which is dissolved a little of Hudson's Extract of

Soap. If a bird is the subject, never allow the feathers to be wet longer than is absolutely necessary, and extract as much moisture as possible with a dry duster. Then saturate the feathers with benzoline, sprinkle plaster of Paris over them, beat the plaster off again at once, and repeat the process, using fresh plaster and adding more benzoline until the feathers appear dry.

Benzoline is a solvent of grease; it also forces out the water contained in the feathers and prevents the plaster from setting, but quick beating is required when the first plaster is applied. The plaster absorbs the grease dissolved by the benzoline and also cleans the feathers, but the skins must be thoroughly beaten to get the plaster off. If the skin has no blood on it, the soap-powder and water will not be required, and much time will be saved. This recipe will also answer for the treatment of small and large animal skins.

The composition for stopping up and repairing holes is made by mixing melted glue and well ground whiting to the consistency of stiff dough; the amount of glue must be determined by testing the composition with the fingers. It should feel tacky and stick to the finger; if it crumbles, add more glue. When worked well together, add one tablespoonful of boiled oil for every pound of glue used, and knead the constituents until they are thoroughly mixed. The composition can be used after it has become cold and hard, by steaming it.

In fixing artificial eyes, modelling nostrils, lips, tongues, and the innumerable requirements of taxidermy, this composition is used. It can be made to imitate any surface by manipulating it properly, and is easily coloured.

Arsenical Soap. This is made of 3 lb. white curd soap, 3 lb. arsenic powder, and 8 oz. camphor. Slice up the soap and melt over a fire in as much water as will just cover it, and stir well to keep it from burning. Crush the camphor very small, with a little methylated spirit, and add this together with the arsenic powder. The whole should form a creamy paste. Arsenical soap has been decried by some taxidermists, but it still holds its place with the trade, and will do so until a better preservative is found.

Treatment of Skins for Storing. Animal skins are sometimes found infested with a pernicious insect (*Derm·s'es*), the grub of a small beetle. It is the most destructive insect with which the taxidermist has to contend. It eats through the toughest skins, and it has been known to eat through cork. When this pest is found in any specimen, instantly saturate everything in the same case or box with turpentine, and keep the case closed for a short time.

Naphthalene crystals are very good to use in boxes of specimens of all kinds. Cyanide of potassium is a dangerous poison, but a powerful insecticide if placed in boxes of skins; it should be enclosed in a block of plaster of Paris, the cyanide being placed in the plaster before it has quite set. If it is not enclosed in plaster, the chemical will absorb moisture, and run on to the skins with which it is in contact and spoil them.

Natural history specimens should be stored in a very dry place, as dampness will induce the attacks of insects. A periodical overhauling is essential; brushing the skins and exposing them to the sun for a few hours is a good plan.

Cabinets of insects are subject to the attack of a mite which eats the tissues of the body, causing the wings and legs to fall off. The presence of this pest may be noted by the dust which surrounds the insect affected. The best remedy is benzoline, or petrol will also do. Run the spirit into the drawers until all the contents are saturated; close up the cabinet and allow the spirit slowly to evaporate; it will not leave a stain. Be careful in using this spirit, as it is very explosive; keep all naked flames from contact.

If cases containing stuffed birds and animals are found to have moths inside, which sometimes happens in old cases that have become damaged, a saturation with petrol will stop the ravages of the insects, and kill the grubs, but the specimens will have to be watched, as the spirit will not affect the eggs of the insects, which may still exist and hatch in a week or two.

Hints for Big-game Hunters. In most instances the actual skinning of big game is done by natives, but the sportsman who values his trophies will find it pay to supervise the work, and see that due precautions are taken to preserve the specimens, as their enemies in the tropical regions are more numerous.

Reducing the baggage to a minimum is a consideration, but the hunter should on no account proceed without a good supply of powdered alum, which must be stored in conveniently sized tins (a lion's skin requires about 3 lb. of alum to cure it).

When an animal has been skinned, and all surplus fat and flesh have been cleaned off the skin, it should be well rubbed with alum, and then should be rolled up to allow the alum to dissolve and penetrate the skin.

The action of alum is astringent; it shrinks the skin and thereby keeps the hair firm. Great attention must be paid to the eyelids, nose, mouth, and ears, to get them well saturated with alum.

After about eight hours, the alum having done its work, the skin should be pegged out flat, flesh side upwards, *in the shade*. On no acount should a skin be allowed to dry in the sun, as this will burn it, making it brittle and quite useless for any purpose. If, by any accident, alum is not available, dry wood-ashes are a good substitute.

Horns, trophies, and skulls should have all flesh removed, and if time permits may be placed inside an ant-hill. These insects will rapidly eat away all vestiges of gristle and flesh, leaving the bone as clean as if it had been boiled. The skins should be hung in a situation where ants cannot reach them, or much damage will result.

On reaching the coast all skins and trophies should be overhauled before being packed for shipment, and saturated with crude turpentine. This will ensure their safety during the voyage home. Many valuable specimens have been irretrievably damaged through neglecting this simple prevention, the insect pests having been packed up with the skins, and completing their work of destruction undisturbed in the packing-cases.

TOBACCONISTS

The annual licence to sell tobacco by retail costs but the modest sum of 5s. 3d. The trade itself, as often conducted, demands no great skill or experience, and it is but natural that many people without either should turn to this trade as a means of livelihood, or of ekeing out the profits of another business, such as that of a hairdresser, grocer, newsvendor, confectioner, or publican. The publican's tobacco licence is held for the same period as his spirit licence; when held apart from such a licence, that to sell tobacco and snuff is

renewable in July each year. It is unnecessary, perhaps, to point out that while the trade is so easy of entrance that even young women and widows practise it, this very fact exposes the beginner to all the more competition. Moreover, in most towns very smart shops are now run by companies and firms which have reduced the business of retailing, and certainly their window-dressing, to a fine art.

Starting Business. Since some tobacco-shops are the smallest of all shops, while others are among the most brilliant and imposing, there is obviously a very wide range of choice. The kind of shop, however, will depend greatly on the neighbourhood and the class of customers likely to frequent it. Costly fancy goods and high-priced cigars and pipes, which are the most remunerative portions of a high-class tobacconist's stock, would be quite out of place in a shop where the customers are likely to belong solely to the artisan class. Having selected his "pitch," the intending tobacconist will probably lose little time in studying the advertisements of the trade papers, and he will therein discover the existence, both in London and the provinces, of obliging firms who will supply him with "mixed parcels" of goods at almost any figure he cares to name. Of "proprietary" goods there is a bewildering variety from which to select; it would be well to try to learn the tastes of the expected patrons as far as possible before buying any large stock.

The Shop. In a tobacconist's shop the window is of primary importance. Most of the up-to-date windows are of plate-glass and occupy the whole front of the facia. To facilitate dressing, the whole window-fitting is sometimes removable, or made to revolve. Plush-covered shelving is much used for the attractive display of pipes, cigar-holders, silver goods, etc.; and mirrors at the back and sides usually assist the effect greatly. The beginner will find it worth while to pay a visit to London or one of the larger towns in order to inspect specially the tobacconists' windows and their arrangements.

Much depends on a bright window display; the duller the neighbourhood, the greater the contrast and the effect thereby gained. In dressing the window it is well, if possible, to show loose tobacco. For cigars and cigarettes, dummy boxes or packets can often be used to save the deterioration of stock. For the interior of the shop a few medium-sized shelves will be useful, and have in the counter some good-sized drawers. For storing tobacco a light, well-ventilated, and dry cellar is desirable, the leaf being kept in wooden casks or glazed earthenware jars with loose tin lids. In the shop the tobacco most in demand may be placed in the counter drawers, which, if not of hard wood well planed, should be lined with zinc.

Cigars require different treatment and a higher temperature. If the shop itself is fairly well heated they may be placed on the upper shelves; but at the seaside a proper stock-room, however small, will be needed to save them from the destructive effects of the salt, humid air. Such a room should have, if possible, boarded walls, not damp and clammy stone; and artificial heat may be provided by steam pipes or by a siphon gas-stove consuming its own fumes. Where a room is not available, a suitable stock-room of small dimensions may sometimes be partitioned off at the back of the shop.

Treatment of Stock. With cigars the great thing for the retailer's attention is their proper "conditioning"; with tobacco, the avoidance of mildew. Both these depend on proper storage. British cigars, of which an ordinary stock will comprise perhaps 75 per cent., are seldom sent out "conditioned" by the manufacturers, though the wholesaler may complete the process before the cigars reach the retailer. To condition them, cigars, after leaving the factory, have to be subjected for several weeks to a temperature not less than 60° or more than 80° F. Though the outer wrapper may seem dry and may crackle when pressed between the fingers, and though the ends may be brittle—the signs of a conditioned cigar—the "filler" inside may still be sappy and damp. Even a bad cigar may be improved by conditioning. For this process, steam-heat is the best. To allow the cigar moisture to evaporate under the heat, it is well to prise open the lids of the cigar-boxes a little, or else to bore in the boxes a few gimlet-holes, taking care, of course, not to injure the cigars. The great importers of Havana cigars keep them in London in a constant temperature of about 65°. Speaking of Havanas (spelt Habana in Spanish), it may be mentioned that the colour-marks are as follow: "Claro," very light, very mild flavour; "Colorado claro," light and mild; "Colorado," brown medium; "Colorado maduro," dark brown and full flavour; "Maduro," dark and very full flavour.

Quality of Cigars. But it is said to be a mistake to suppose, as many smokers do, that the very light cigars are necessarily the mildest. The properly matured leaf, which smokes milder, is also a little darker than the immature leaf, often used for wrappers on account of its light colour. When the plant is perfectly matured before cutting, the leaf, although there are light and dark shades of it, is generally of a rich brown colour; and experts aver that such wrappers, when properly worked, will have a sweet and mild taste, even the darkest colours. A retailer samples his cigars by smoking one taken from the second layer in a box, and also by running a sharp penknife down the centre of another to learn the character of the inner wrapper and the "filler." In the smoked cigar the ash is not an infallible sign, though a white ash is usually good (especially in the cheaper lines), and grey inferior; but whatever the colour there should be regular burning. The better class of cigars should have a dull, slate-coloured ash, and should crackle crisply when gently rolled along the palm of the hand.

Precautions against Mildew. With regard to tobacco, mould is a great enemy to the "rolls" and "cuts," and any leaf that is moist. When tobacco parcels are received they should be opened out and inspected without delay, and if not found satisfactory returned promptly to the manufacturer; if only a little heated, turning over and airing may be all that is necessary. The amount of moisture in the tobacco being strictly fixed by law, it may be presumed right in this respect when received from the manufacturer; and the retailer's problem is to keep it so, preventing loss to himself by evaporation and avoiding the opposite error of forbidden moisture. Evaporation may be prevented by covering all tobacco each night with a double thickness of canvas wetted on the upper side, the tobacco being turned over with the hands next morning; or if the tobacco gets too dry the outside may be sprayed with pure cold water applied by a diffuser such as is used for perfume, but care must

be taken against overdoing this. Tobacco kept in casks should be turned over and shaken occasionally to prevent its becoming sodden at the bottom and generating the heat which produces mildew.

The same advice applies to the earthenware jars. Every ten or twelve days or so, empty and inspect these receptacles, and note carefully whether any tiny white specks—the fungus of mildew—are scattered through the tobacco. Your jars should be carefully wiped out with a coarse cloth; and the empty casks—the contents may be temporarily placed on a sheet of brown-paper in the cellar—should be cleansed by a blaze of paper, followed by the application of the dry cloth. Roll, cake, etc., are less likely to become mildewed, olive oil being used in their manufacture; where any sign is found, a little Lucca oil should be applied with a soft brush. Note that the quantity of oil, like moisture, is strictly limited by the law. Cheap tobaccos, which "go off" quickly, are sometimes kept in galvanised iron buckets, which can be turned out and easily brushed clean every morning. Packets of tobacco, now so largely sold, should not be stored in a damp place; usually the shelves under the counter will serve for this purpose. For "smalls," which accumulate in weighing up, and so on, keep a special receptacle, and from time to time return the contents to the manufacturer, who will allow for them. Every retailer should endeavour as soon as possible to sell his own "mixtures." Businesses have been started on a capital of £25, but this is rather a small sum to begin with.

Pipes and Fancy Goods. In the selection of these the tobacconist should aim at showing a stock that will be representative and comprehensive of whatever his clients are likely to require, remembering that unsaleable stock, even though it may show a good profit, as these goods often do, is capital lying idle. Without going into detail, we cannot do better than recommend the beginner to study the catalogues and lists of special assorted parcels that are sent out by various sundriesmen in the trade. In these lists will be found full information also as to terms and discounts.

Side-lines. The side-lines most commonly run in connection with the tobacconist's business are walking-sticks—which often pay very well, especially in seaside or other tourist towns—news-agency, hairdressing, stationery, cutlery, fancy china, leather goods, etc. It is necessary to bear in mind that when heavily plated articles are sold, a plate-dealer's licence may be required. For gold above 2 dwt. and under 2 oz., or silver above 5 dwt. and under 30 oz., a licence costs £2 6s. Expensive sticks and the better class of cigar and cigarette cases, etc., may come under this head, but it is just these high-priced goods that, as a rule, return the retailer his highest profit.

Legal Notes. Mention has been made of the restrictions imposed by the law upon the quantity of water and oil permitted in tobacco. Another point to be remembered is that "Cavendish" or "Negro-head" tobacco, which has to be manufactured in bond, is supplied to the retailer in packets bearing the Government stamp, and this stamp has always to be obliterated when the packet is sold. Care must be taken, however, not to break the packet until it is sold, as this is not permitted by the Excise regulations. Note that the Excise officers have the right to enter and inspect the contents of any place licensed for the sale of tobacco; and if adulterated tobacco is found on the premises, or if any tobacco or snuff is wilfully concealed, the tobacconist renders himself liable to a penalty of £200 and forfeiture of the goods.

TOY MERCHANTS

The retailing of toys and games may be divided into two classes. In the one case the stock would comprise inexpensive articles, and would not cost a great deal to purchase; in the other, the department would include outdoor games and expensive indoor apparatus, such as billiard-tables, bagatelle-boards, phonographs, lanterns for enlarging, cameras, and, indeed, all the paraphernalia which are required for recreation and sport. The first class affords a capital opportunity for ladies desirous of starting in business; the second would require the superintendence of someone with expert knowledge of the rules which govern golf, tennis, cricket, football, billiards, and the rest. Indeed, from £300 to £500 might easily be sunk in this class of stock, which is listed at prices carrying a range of discounts from 15 per cent. in the case of billiard-tables, to as much as a third in the matter of tennis-rackets, cricket-bats, etc. Moreover, this side of the business requires rather large premises, or at least a good shop-front, and a light, open showroom behind. It cannot be conducted without a moderate amount of local advertising; and even if the proprietor is in quite a small way, the salary of at least one assistant would have to be met, unless the proprietor lives on the premises and is prepared to be tied to the place during business hours. Thus, assuming a sporting games stock of £500 can be turned over three times in a year, and taking the average discount at 25 per cent., the gross profits would be between £350 and £400, out of which all expenses, including rent and rates, would have to be met before the proprietor began to take his profits. It will be seen, then, that a young man with a small sum to invest will find in this business an opening which will return him a moderate income. Of course, a £1500 return is by no means the limit possible, especially if in time the proprietor can add cycles or sporting games, or both.

Our immediate concern, however, is with toys, in the more generally accepted definition of the word. This, as has already been pointed out, is a business which appeals to women. It can be carried on in comparatively inexpensive premises; a hundred pounds' worth of stock goes a long way towards making a brave show, and success does not depend upon a large population. There are children everywhere, and therefore customers.

Stock. The stock to fill a shop of good class, such as we have in mind, would not cost much more than £100. Practically the whole of it would be purchased at prices which represent from 25 per cent. to 33⅓ per cent. off the selling price. It would be subdivided into a variety of sections, appealing to different ages. First, there would be toys to retail at from 1d. to 6d., the kind of things that we associate with Christmas-trees at year-end parties. Penny toys cost from 7s. 6d. to 8s. 6d. per gross; toy-picture-books, 2s., 2s. 8d., 4s., or 8s. a dozen, as they are intended to sell at 3d., 4d., 6d., or 1s. respectively. Dolls, for which there is a steady sale, carry similar profits, at from a penny apiece upwards.

For older boys and girls every season brings with it a fresh batch of games for the table. Outdoor sports in miniature, which are not always successful copies of the original, sell freely at all times, including table bowls, croquet, etc. Besides, there are old-established favourites for the table, such as

Halma, draughts, race games, Ludo, not to mention chess and backgammon.

Cards and Card Games. For all ages there are cards, comprising bridge, whist, bézique, Patience, etc., which are sold under a Government stamp, and dozens of others, including Snap, Happy Families, and other old-fashioned games which refuse to be counted out of date. Besides, a number of new ones, some of them of American origin, have sold freely in recent years. Most of these are sold in various editions, costing from 6d. to 3s. per pack or set, which prices also carry a discount of from a quarter to one-third.

Mechanical Toys. These are splendid sellers; and if a group are arranged to run in a window during business hours, a crowd is always to be found round the retailer's shop-front. The variety of mechanical toys is remarkable, and behind all those which have been mentioned are trams and rolling stock, operated by clockwork, steam, and even the electric current on the three-rail plan of the District Railway. In this department, again, discounts run ordinarily to a third.

Salesmanship and Buying. Selling toys requires patience and a pleasing manner. Children are not attracted by the typical business face and bearing. They not unreasonably and quite unconsciously assume that selling toys is an interesting as buying them, and success comes only to those retailers who can win the goodwill of the little folk. Sixpence to many a child is a little fortune, and not to be spent without first weighing the relative merits of many articles. Even parents are difficult to please in this matter, with the result that what appears to be a simple matter is really one calling for no little tact and courteous attention.

Buying, of course, calls for care, and a due recognition of local circumstances and the seasons. In most big centres there are large warehouses where novelties can be seen and stock selected. The chief of these are to be found in Houndsditch, in London. A visit to these centres twice a year will afford better opportunities of replenishing stock than haphazard purchasing from travellers or by post from catalogues, in which the descriptions of the stock are ordinarily more artistically adorned than accurate.

UNDERTAKERS

Generally speaking, the duties of an undertaker are to measure the dead body, to make the coffin, to arrange with the cemetery authorities, to provide the carriages and men, and to accompany the funeral to the grave. There are funeral furnishers, however, who do not come directly into contact with the mourners. They may be wholesale manufacturers or jobmasters, providing the undertakers with coffins, carriages, and all the appurtenances. In most cases the undertaker, however, makes and furnishes the coffin, and applies to a known carriage-master for hearse and fittings.

The Shop and the Workshop. Having a bank balance of at least £200, the young man —he should be at least 26 to 30 years of age— would look around for a suitable site to begin operations. First of all, he would endeavour to secure a roomy, well-lighted workshop, preferably with an adjoining sale-shop fronting the main street. Perhaps this will not be easily secured, and, if so, separate establishments within easy distance of each other would be selected. In any case the workshop must be dry and well lit, in a good locality, and with convenient access. Plenty of light is required for the work; even black stuff is "sore on the eyes." Such a workshop would cost £10 to £20 rental (or more if in London), and it would be divided into two portions. One part would be wood-lined, and fitted with shelves for the finished shells, for cloths, linings, or general ironmongery, all of which must be kept dry. The other division would be used as the workshop proper. It would contain one or two small benches with vices (costing £4 for two), half a dozen trestles for use in the shop, and the same number for use at funerals (£2); and, where possible, a small electric motor and a small saw-table. A motor (one horse-power) would cost about £14, a saw-table £12, and shelving about £5. The sale-shop should be divided into a front apartment for callers, and a private room behind. In the front shop there had better be a small counter, a desk, and a few chairs, shelving round the walls, and a few drawers. On the shelves there would be displayed wreaths, flowers, brass mountings, or anything else that could be exhibited. The drawers are for funeral stationery, and a selection of grave-cloths, shrouds, and linings. The private room at the back should be fitted with a writing-table, chairs, and the usual office furniture. The fittings of the front shop and private room, including floors covered with floorcloth or linoleum, should not cost more than £20 all told, and the rent of both shops in conjunction would probably be £40 to £60 per annum, according to locality.

The Stock. As in most businesses, there are wholesale factors or manufacturers of the various articles required for the trade. There are manufacturers of all kinds of wreaths (artificial and natural), coffin furniture, special wood, mouldings, etc., of coffins, besides cloth, linings, and so forth. With regard to wreaths, it is often advisable for the beginner to have an arrangement with a local wholesale florist, but, failing that, there are many regular wreath factors in the trade ready to supply all kinds of mementos on demand. For an opening stock, four marble wreaths, with stands, of assorted kinds, would be necessary. These would cost about £8 15s. Then six enamel wreaths would be ordered, at a cost of about £1 16s., and one dozen preserved flower wreaths (18s.). A suitable selection of inscription glasses, vases, and graveside decorations could be obtained for £1. In stationery, funeral cards (such as are given to cord-holders and pall-bearers) would cost about 12s., while ordinary office stationery and books would absorb another £2 10s. That is all the stock necessary for the sale-shop. For the workshop the stock would include 1 doz. assorted deals of oak, ash, and elm, cut to ¾ in. thickness (£5 8s.); 300 ft. of suitable mouldings (£1 5s.); 1 doz. deals of third quality yellow pine, red pine, or white pine (£3 6s.), and 40 yds. of lining for bottoms (£1 13s.). These would all be stacked, dried, and used as required. Then in cloths for covering or lining coffins, etc., there would be obtained one piece each of black (£2 5s.), white cotton (15s.), and embossed (£1 3s. 4d.), and half a piece of velveteen (£2 6s.). The black cloth is in 45-yd. lengths, the white and the embossed in 40-yd. pieces, and the velveteen in 30 yd. Besides these, there would be 2 doz. side-sheets (for placing up the sides of the coffin and folding over the body), one quality costing 10s. 6d. per doz., the other 7s. 6d.; ½ doz. embossed sheets (9s.), and four sets of best sheets (18s. 6d.). Frillings would cost at least 9s.; six shrouds would be 16s., and 1 doz. assorted grave-gowns £1 10s., while six sets of silk cords (£1 2s.) and 2 doz. sets of assorted cheaper quality cords

would mean another sovereign. One piece of waterproof sheeting, which is often used in place of zinc lining, would cost from 40s. to 48s. In ironmongery, two sets of brass mountings at £2 10s., two sets costing £2, four sets costing £2, and four sets costing £1 2s. would give a very fair selection. These might be assorted brassed and nickel-plated. A "set" includes one name-plate, side-plates, and handles for cords; and where black coffins are used it will be necessary to have black or white mountings and lace. In such cases, four sets of black and four sets of white, for adults (3s. per set), and six sets for children (1s. 6d. per set), would suffice. Another 15s. would be spent on the ordinary nails and screws.

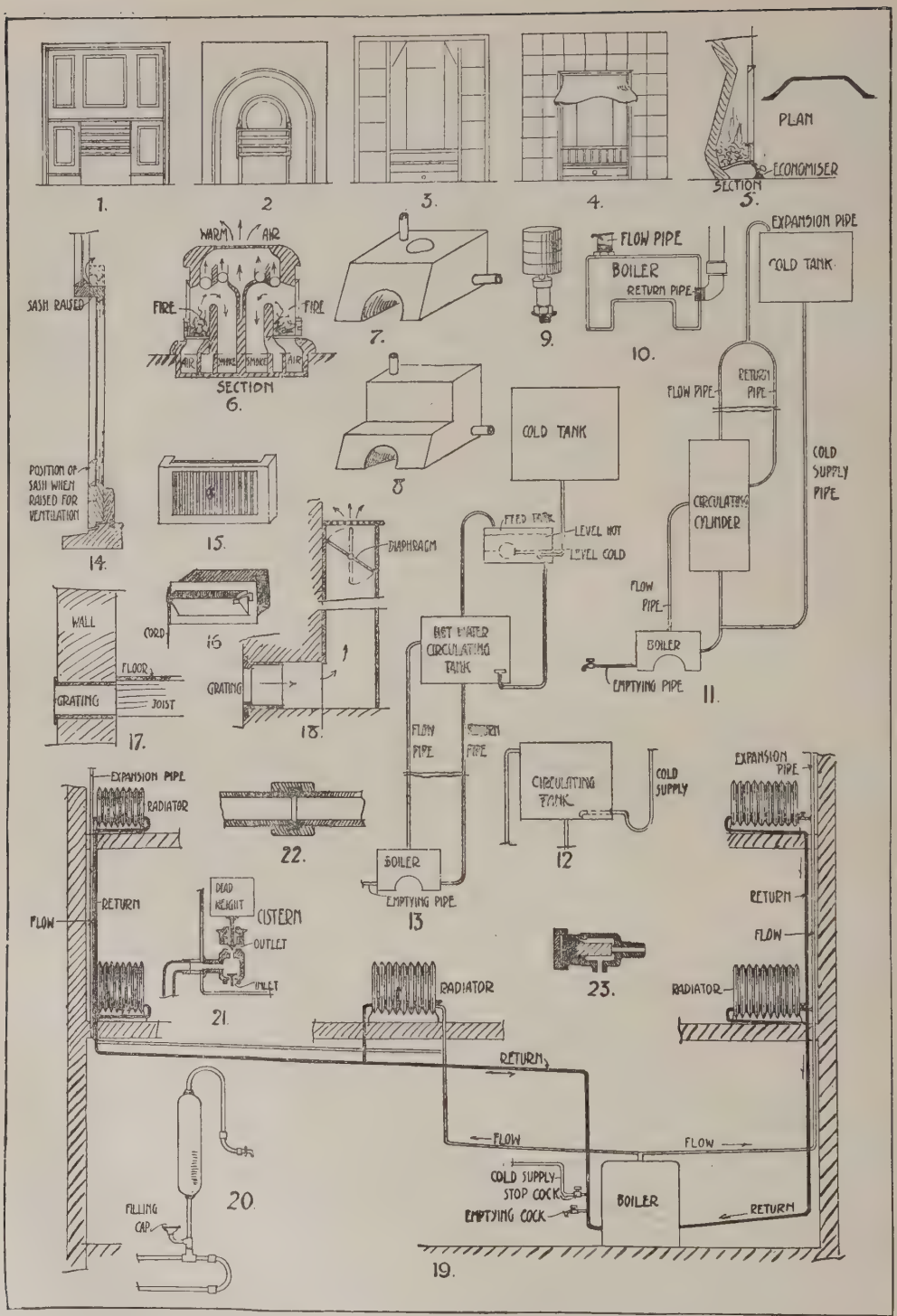
The Method of Procedure. When the relatives of the dead call, they should be ushered into the private room, where all particulars must be noted in a book kept for the purpose. These include the name and address of the person giving the order (for he or she is responsible in law for payment), the name, age, and occupation of deceased, the cause and date of death, the name of the doctor who attended at the death, particulars of the burial ground, if any, when the coffining or "chesting" is to be done, the hour and day of the funeral, the service desired, the style, quality, and price of coffin, and other questions regarding local customs or particular desires about which you may not be sure. In measuring the body, one must take the exact length, width at the widest, and the depth. The coffin should be made inside at least 2 in. longer and 1 in. deeper than the actual measurements. The finished coffin should be delivered punctually at the time appointed. With regard to screwing down the lid, local custom and the wishes of the relatives have usually to decide. The funeral arrangements differ in many localities, and it is the business of the undertaker to learn local customs. In lifting out or in, in public, the coffin must be always carried feet foremost.

The Question of Prices. Prices are affected by many things—wages, rents, facilities, and the character of the opposition. They should be neither too high nor too low, but commensurate with a good class of business. The ordinary charge for an adult coffin averages about £3, but for customers in a poorer station of life a lower charge should be made, without loss of profit, by reducing the quantity and quality of the materials and furnishings. Varnished pine coffins of better qualities and richer mountings average about £4 4s.; plain oak or elm, £8 or £9 if polished, and higher prices for the best quality and superior finish. Where cords and tassels with brass side-plates are used, 15s. to 25s. would have to be added, and often the coffin requires a zinc lining, which would increase the price by about 12s. 6d., or, if soldered down, by about 20s. Attendance at an ordinary funeral is generally reckoned at £1; but where coffins are lined, extra assistance is required, and the charge would then be 30s. When country journeys or travel by train are undertaken, the charge is usually 10s. per man and £1 for the undertaker himself, plus all outlays. Carriage by rail for a corpse is 1s. per mile, but an empty coffin is carried at the usual parcel rate. For undertakings to long distances hires may be wanted at both ends, and this increases the expense. The cost of hires will vary according to the style of funeral carriage and the horses. A plain hearse should run from 8s. to 10s. upwards per funeral, a pair-horse carriage from 21s. to 30s., or more. Single carriages for the mourners are usually hired at from 5s. to 7s. 6d. each, and pair-horse carriages from 15s. to 21s., according to style.

Profits and Credits. The safe plan is to have a regulation scale of prices for coffins, which will include ordinary attendance, then add hires (from which a small commission is received) and out-of-pocket expenses. For an ordinary undertaking a clear profit of not less than 25 per cent. should be received. For such as call for a good class of oak coffin, with more stylish work, proportionately higher charges are made and greater profits accrue. The usual credit given by the wholesale trade is one month, with 2½ per cent. discount. The undertaker should insist on doing a cash trade, for it is easier to get the money during the first flush of grief than later on, when the fountains have dried up somewhat. If there is any suspicion of pecuniary insecurity, a surety or a deposit should be insisted upon, and no discounts should be given.

Cremation. There are several crematoriums in various parts of the country, the principal being in the neighbourhood of London. Woking and Golder's Green are, perhaps, the best-known places, and the proceedings are under the direction of the Cremation Society. When a wish for cremation is expressed, application in writing must first be made to the company by the executors or nearest relatives of the deceased (unless the deceased has already communicated such a desire during his or her lifetime), stating that it was the wish of the deceased to be cremated, or that he, or she, entertained no objection thereto. Upon receipt of instructions, regulation application forms are sent by the Society, which are filled up and sent to the undertaker, who makes all the necessary arrangements. Two certificates from medical men (one of whom must have attended the deceased), stating the cause of death, are required, and the names and addresses of such medical men should be given in full. The Cremation Society reserve the right of refusing to carry out a cremation without assigning any reason. Cremations may take place two days after receipt of application form. The registrar's certificate is required, as in ordinary burials, and it is imperative that it be sent to the undertaker without delay, as the Society requires its production before the order for cremation can be issued. A pine shell, covered or polished, is sufficient to carry the body. Cremation being considered only a process preparatory to interment, the Bishops of the Church of England have ordained that the Burial Service, which includes the committal of the body to the grave, should not be read until the ashes are brought to the churchyard for interment. This does not, however, preclude a service being held in the chapel, if desired, prior to cremation. The fee to the local clergyman, if retained, would be £1 1s. The fee for cremation is usually £5 5s., alike for adults and for children.

As a guide to cost, one might assume a cremation at Woking from London. There would be conveyance of the body from any metropolitan station to Waterloo, with hearse and men, railway charges to Woking, hearse and pair from Woking to crematorium, attendant from London, cremation fees, making necessary arrangements with Cremation Society, supplying casket and brass plate; in all, about £15 10s. for net cash. In estimating, the undertaker would add charges for his personal expenses, and would leave a margin for any telegrams or incidental outlays that might be necessary.



1–23. HEATING AND VENTILATING APPARATUS

1. Hob grate **2.** Register grate **3.** Slow-combustion grate **4** and **5.** Modern grate with economiser **6.** Hospital ward stove **7.** Saddle boiler **8.** Boot boiler **9.** Safety valve **10.** Connections of flow and return pipes **11.** Circulating system with cylinder **12.** Connections of pipes to tank **13.** Circulating system with tank **14.** Ventilating sash **15.** Hit-and-miss ventilator **16.** Hopper ventilator **17.** Ventilation under floors **18.** Tobin tube **19.** Low-pressure hot-water heating system **20.** Expansion tube **21.** Combined inlet and outlet valve **22.** Joint for high-pressure hot-water pipes **23.** Expansion plug

Heating Installations. Natural and Artificial Ventilation. Dr. Hill's Experiment. The Hot-Water System. Lighting Systems.

HEATING, VENTILATING & LIGHTING

Some means of artificially raising the temperature of living-rooms during at least part of the year is essential in this and in many countries; and, apart from this, it is necessary to provide for the means of cooking food and heating water for domestic use. These requirements may be met in a variety of ways, depending to a considerable extent upon custom, but varying with the circumstances of the building to be dealt with.

In ordinary dwellings in this country the open fire is the usual method of warming rooms. The general improvement in hot-water heating, however, has brought central heating on this system into very general use, and it is unusual to find a new house of any size that has not such a system installed. Moreover, an indication has shown itself during the last few years that there will be a demand for low-pressure hot-water heating apparatus in the small, £30 to £40 a year houses which are so numerous in the large towns and cities of England. There are certainly many such already in existence. At the same time it does not appear probable that any form of heating apparatus will quite supplant the open fire, which has several features of particular merit, some of which have not long been recognised.

The Problem of Heating. Perhaps the best means of bringing to light the advantages and disadvantages of the various methods of heating and ventilating is to consider in some detail the problem to be solved.

No one can deny that a man who spends his life in the open has the best chance of keeping himself in perfect health. A very great number of the illnesses to which we are subject are known to doctors as "indoor diseases." The problem we have to solve, then, is to keep the air conditions inside our dwelling as nearly as possible like that outside. As, however, those who pass their time indoors are generally occupied at some task or amusement which debars them for the time from exercise of any kind, we are confronted with the added difficulty of maintaining the internal condition of our dwellings as nearly as possible like the outside conditions in summer time, when we can sit out of doors in perfect comfort.

We get an insight into the external conditions by regarding the temperatures in the sun and in shade. The sun temperature is always several degrees above the shade temperature. The latter is, of course, the air temperature, while the former is the temperature of the radiant heat of the sun. A difference in air temperature and radiant temperature, then, is one of the essential features for which we should strive within our dwellings.

Out of doors, again, there is nearly always air moving, and this has recently been shown by Dr. Leonard Hill, Professor of Physiology at London Hospital, to be a matter of vital importance.

The humidity of the air is another important feature. Out of doors we get a constant variation, but in Nature it is always preserved within limits that are suitable to health. Air automatically takes up and deposits moisture with every change of temperature. In our country, surrounded as it is by the sea, we never experience anything out of doors approaching the dryness of desert air. It will be shown, however, that within doors this is by no means unusual. Again, in a crowded room which is improperly ventilated it is a very common thing to find air absolutely saturated, and this air, moreover, clings around the occupants in the part of the room where it does most harm.

Dr. Hill's Experiment. Dr. Hill has shown this by an experiment which is so significant and interesting that it is important to describe it. He has had made a small air-tight chamber, with one glass wall intended to permit careful observations from the outside. The chamber measures three cubic metres. Into this small space he crowded eight or nine students, and hermetically sealed them in.

It is easy to imagine what happened. The students who were imprisoned soon lost the jovial humour in which they entered on their task, and it was clear within a quarter of an hour that the conditions were becoming uncomfortable. The thermometer inside the chamber was seen to be quickly rising, and an analysis of the air showed an increase of CO_2 (carbon dioxide). This was, of course, due to the respiration of those inside, oxygen being used up in the process of breathing and CO_2 being given out. This is a product of the combustion which is always going on in our bodies. The quantity of aqueous vapour in the air also increased.

Dr. Hill had an instrument for measuring the volume of the air which each man inhaled at each inspiration. It showed a continual increase during the course of the experiment. The rate of breathing also increased. At the end of half an hour the men were showing signs of acute distress. The temperature by this time was more than 80° F. Their heart-beat had become very rapid. They were suffused with perspiration, which could not evaporate, because the air had become saturated, and each man's temperature had risen above the normal. Very careful observation was, of course, kept to note if the condition of any of the men became critical, for it must be remembered that they were being slowly suffocated.

At last a point was reached beyond which it was not deemed safe to go, and then two small electric fans, which were fixed in a horizontal position just below the ceiling of the chamber, were switched on. These fans were not connected to the outside. The only result of their motion was to set up a current of air inside the chamber. The immediate effect of that air movement was wonderful. The students thought that a current of fresh air was being introduced from the outside. Immediately they revived. One of them afterwards described his sensations, and said it was like coming out of an oven without any air in it, and passing on to a headland by the sea on a bright, fresh day. All the men were examined medically, both before and afterwards, and were pronounced to be none the worse for their experience.

Deductions from the Experiment. The experiment is remarkable, because it brings to light entirely new features in the ventilating question, and also shows us that some of the formerly accepted principles are valueless. Perhaps the most important is the fact that what was formerly spoken of as the chemical impurity of the air, measured by the amount of CO_2 present in it, is of very little importance. As long as the added CO_2 is evenly distributed throughout the entire room, it does practically no harm at all. As it can be evenly distributed with air movement, it accentuates the importance of this movement, which, it will be remembered, is one of the conditions prevailing out of doors.

Incidentally, it also shows that the vast volume of air which under the old rule was considered necessary to keep the CO_2 in the air down to 6 parts per 1000 (the figure which was arbitrarily fixed as the point of maximum impurity for air in buildings) can be very greatly modified.

The Effect of Stuffy Rooms. The real cause of the acute suffering to which the students were subjected before the fan was set in motion was the clinging film of hot, moist air which occupied the space in which they were compelled to breathe. This caused the rise in bodily temperature, because the protective mechanism with which we are provided for counteracting the tendency of our normal temperature rising was put out of action by the moisture surrounding them. This mechanism, one of many found in the human body, is interesting. When our temperature begins to rise on account of any external cause, the blood stream is diverted from the internal organs of the body, and flows through the system of veins which lie just beneath the skin. This produces moisture on the skin, which we know as perspiration. The cooling effect is brought about by the evaporation of this moisture. In the case we are considering, the blood performed its part of the function and produced the moisture; but on account of the condition of the warm, saturated air immediately surrounding the students, the evaporation could not take place, and thus no cooling effect was produced. In the same way, and under the same conditions, the blood stream flushes the respiratory tract, which exudes mucus.

That these phenomena do occur has been very satisfactorily proved; and if confirmation is needed we only have to remember the flushed faces of those who have spent some time in a hot, stuffy room. An examination of the throat also shows that the pale pink colour which is characteristic of the normal condition has been changed to a bright red colour. The risk of catching a cold, to which one is subject on going out into the cool air after leaving a hot room, we all well know, and the condition of the mucous membrane which surrounds the respiratory tract fully accounts for it.

The deep and rapid breathing of the students was certainly uncomfortable but not harmful. It was an involuntary effort to obtain the necessary amount of oxygen from a mixture which had been considerably depleted of that gas, and had in consequence to be delivered into the lungs in larger volume in a given time.

It must not, of course, be assumed that there was no danger in the experiment, for undoubtedly there was. The glass wall of the chamber was provided in order that it might be seen when the condition of the students approached a critical stage. Had the fan not been started, the temperature of those inside would no doubt have risen to a dangerous extent, and the air would in time have been so depleted of oxygen that the effort of drawing in a sufficient quantity to get the necessary amount of oxygen to sustain life would have been too great.

The value of the experiment lies in the fact that it showed that by circulating the air it was found that there was still sufficient to sustain life in comfort, in spite of the extreme smallness of the chamber, and also that it brought to light the importance of keeping the amount of moisture within reasonable limits, and of that air movement which is now known to be so essential to health.

Essentials of Ventilating and Heating Systems. The chief points, then, which we must endeavour to reproduce indoors when we undertake the warming and ventilation of our houses are as follow:

We must have a source from which heat is radiated, and the temperature of this radiant heat may be considerable. The intensity varies inversely as the distance, so we can move away if it is too intense.

We must have moving air.

The temperature of the air should be about 60° F. If it is lower, there is a chance that we shall feel chilly when sitting down.

If the room is not a crowded one, the humidity may be anything from 70 per cent. to 100 per cent. When we are sitting still in a temperature of 60° we do not perspire much, and this is an indication that there is no tendency for our normal temperature to rise. The humidity should not be allowed to fall much below 70 per cent. In other words, the air should not be allowed to get too dry. If it does, it greedily evaporates moisture, and even the moderate amount of perspiration which normally covers the skin is quickly taken up, and this produces a chilling effect.

It is essential that a moderate air change shall take place, but certainly it need not be so great as we formerly considered necessary.

With these points before us we can more readily appreciate the advantages and disadvantages of the various means of heating and ventilating which are in common use.

The Open Fire. A heated body gives out its heat by radiation, conduction, and convection. [See PHYSICS, page 1403.] The commonest form of house-heating is the open fire, which is an example of radiant heat. All forms of grates are liable to the objection that the fuel burnt in them is wastefully employed, much of the heat passing away with the products of combustion, but some forms of grates are much more wasteful than others. The old-fashioned forms known as the *hob-grate* [1] and the *register stove* [2], of which there were many varieties, were extremely extravagant. In both, the receptacle for the fire was raised high above the hearth, and had vertical or horizontal bars in front and horizontal fire bars below; the air had free access not only to the front and upper surfaces of the fire, but to its under surface, and was drawn up through the fire, and resulted in rapid combustion of the fuel. Such stoves were usually mainly of iron, often with the addition of thin firebrick backs and cheeks.

Modern grates are mostly constructed so that the fire is either close to, or actually on, the hearth [3 and 4], and when slightly raised a movable front, termed an *economiser* [5], is provided, so as to close the opening entirely after the fire has been lighted and is burning briskly. Though varying somewhat in detail, most modern fires have the back and sides of thick fireclay, generally about 2 in. thick, and

the sides are usually placed not square but on a splayed line, while the back is sloped forward over the fire [5]. The object sought to be secured by this form is to make the utmost use of the fuel, which directly heats the back and sides, and these in turn radiate the heat into the room, and, being thick, retain a considerable amount of heat after the fire has died down. All such modern grates are more efficient and economical than the old ones. Some of them have no ironwork at all except the bottom bars. Such grates were first introduced by Dr. Teale. The fire in them is sunk below the level of the hearth, which is raised above the floor level, and access for air is arranged under it by means of an opening which can be closed after the fire is once lighted. The *interior*, as it is termed, in which the fire is lighted, is of firebrick in one or two pieces, and the front may be formed of glazed bricks.

Other fireplaces are formed with but little more ironwork. A metal frame is attached to the front of the interior, which includes the front bars to the fire, and this form is well adapted for use with tiled jambs and top. These are finished behind the metal frame, which may be ornamental in form, and often includes an ornamental canopy, fixed or movable. Iron, brass, copper, and armour steel are used in this work, either alone or in combination, and around the opening there is added an ornamental mantel, and perhaps an overmantel, which is a purely decorative feature and is regulated by taste and means.

The advantages of the open fire at once become clear. It approaches more nearly to the actual outside conditions. We have the source of radiant heat and the moving air at a lower temperature, but it is just at this point that one of its disadvantages is apparent. The air which finds its way into a room, in winter is often so cold that it is felt as a definite and chilling draught. The other great disadvantage is the waste of fuel that is inevitable. It is questionable if the most improved grate has an efficiency of 20 per cent.; and it would come as a shock to a prudent man if he realised that he was wasting £80 out of every £100 he spent in coal.

Ventilating Grates. This form of open fire has a feature which is in one respect an improvement on the ordinary open fire. It warms the air which is drawn in to supply the demand for oxygen of the burning fuel, and so does away with the cold draught. This is effected by forming behind the firebox, or interior, a chamber surrounding the back of the fire, into which the air is admitted cold from outside, and from which it may be discharged, after it has passed round the grate and has become warmed, into the room. Such a grate may be formed with an iron frame having projecting gills at the back, which increase the radiating surface and assist in warming the air.

This class of grate is not very extensively used. The objection to it is that it is generally so constructed that it overheats the air supply, depletes it of oxgyen, and greatly reduces its humidity. Saturated air—that is, air containing as much moisture as is possible—if raised from 40° F. to 60° F., only holds in suspension half the moisture it is capable of holding, and so is reduced to 50 per cent. saturation, which, as pointed out, is *too* low. These limits, which are excessive, are greatly exceeded in ventilating grates. In warming the air supply it brings into operation the third method of heat distribution—namely, convection. This increases the efficiency of a ventilating grate to a higher percentage than that of the ordinary open fire.

Stoves. Heating by stoves is not much in favour in this country, although it has one great advantage: in the stove the furnace is entirely enclosed, and this gives a greater control over the rate of combustion. By checking this, and by using a hard coal, such as anthracite, it is possible to keep the fire always alight. This is a very important point. With the ordinary open fire, we heat up a room when we light the fire, and allow it to cool again when the fire goes out, which it always does during the night. The consequence is that we are always confronted with the daily task of warming up our rooms, which means a large expenditure of fuel before any heating effect is noticeable. With the stove it is possible to start the day with the rooms comfortably warmed.

Ventilating Stoves. Ventilating stoves are sometimes made, and are provided with air chambers and flues, so as to deliver warmed air into the room, as in the case of a ventilating grate. For hospital use a special form of stove has been designed, consisting, in fact, of two open fires placed back to back, so as to stand in the middle of a ward, with chambers and outlets for warmed air [6]. From such a stove an ordinary chimney is not usually taken, as it would occupy the centre of the ward, but a flue is taken down to the floor level, then horizontally in the thickness of the floor to one of the side walls, with proper provision for sweeping it, and then vertically above the roof. The fresh air flue is brought in the same way to the stove from an external wall. Such a stove is efficient, but is subject to the same criticism as the ventilating grate.

Gas Heating. This is receiving a great deal of scientific attention, and as a result has been greatly improved. The modern gas-stove is a very efficient form of heating apparatus, and has been largely used in recent years. In the stoves of best design, the knowledge gained from careful experiment has resulted in a gas-fire in which all the products of combustion are carried away by the flue. This is a most important point. These products are harmful. The claim made by some makers of flueless gas-stove, that they consume the products of combustion, must be accepted with the greatest caution. It can safely be asserted that there is no means known to science capable of application by which such a result can be accomplished. In the modern gas-stove the satisfactory features of the open fire are united, but the cost of the gas is very high—so high, in fact, that their use is generally restricted to small installations.

Electric Heating. This form of heating has been considered in detail on page 2733. It is easily installed, pleasant in appearance, and is free from products of combustion. The cost of current, however, is enormous, and entirely prevents its application on a large scale. It is a convenient means of heating small offices and rooms, on account of its high radiant heating power and its portability. One need not attempt to raise the temperature of any particular room in which it is used. It is generally possible to move the source of heat into a position in which the direct radiant heat can be felt, and a comfortable bodily temperature can be maintained in spite of a low air temperature.

Central Heating. There are several different systems of central heating. Within the last ten years a great advance has been made in this method of heating; most new buildings of any size have a heating plant. The system in most general use in this country is low-pressure

hot-water heating. Water possesses just such qualities which make it a splendid medium for distributing heat throughout a building. Its cheapness, high specific heat, and extreme fluidity are invaluable for this purpose. Its rapid increase in volume, and consequent fall in weight, when its temperature is raised, supplies the motive power which maintains the circulation.

The complete apparatus consists of three essential parts—the boiler where the temperature of the water is raised, the main pipes through which it is led to the points where heat is required, and the radiators where it gives out its heat to the surrounding air. Radiation, convection, and conduction, the three forms in which heat transmission can take place, each take their part in unison. It is for the heating engineer to see that no check is offered to any one of the three, for if one be checked all are checked.

Here the source of heat is the fire within the boiler. Its radiant heat falls on the plates which surround it; convection currents bear the highly heated gases from the fire through the boiler flues, which are heated by contact. The metal plates of the fire-box and flues conduct the heat to the water in contact with the other side; from here the convection currents of the water start out on their journey to the radiating surface. This is heated by contact, transmits the heat by conduction to the outer surface, where it is delivered to the air by contact, and also to some extent radiated into the rooms to be warmed.

How Circulation is Maintained. The circulation is maintained by the difference of temperature of the water in the flow and return mains. It is brought about by the expansion in volume which occurs when water is heated.

Before the fire is lighted in the boiler the water in the system is all of the same temperature. When the fire is lighted the water in the boiler expands and pushes its way into the flow main, which is connected to the top of the boiler. In doing so it causes water in the flow main to overflow into a tank provided for this purpose, which is fixed at the top of the flow main, and is called the expansion tank. Directly this happens, the water in the flow main is lighter than the water in the return main. The latter is connected from the top of the flow main to the bottom of the boiler. The water in it, now being heavier than the water in the flow main, begins to fall to the boiler, and the circulation is started. As it passes through the boiler, it in turn is heated, and so the circulation is maintained as long as the fire is burning.

From the flow main branch mains are led to the radiators. Here the heat is given out, and the water increases in weight again by contracting, and falls through the return branches to join the heavy stream of water passing through the return main on its way back to the boiler.

Design of Hot-water Apparatus. The design of a hot-water heating apparatus is complicated and difficult. The size of the boiler is obtained by adding the number of heat units that are necessary to warm each room, and also those which are given out by the main pipes. These units should be sufficient in number to warm the building to the required temperature in cold weather. The usual figures required are 60° F. inside, with an outside temperature of 32° F. Having arrived at the number of units required, the boiler capable of supplying that number per hour, making an allowance as a safety margin, is selected.

The size of the radiator is determined by the amount of heat that will be given out in cold weather by the different rooms. This depends not so much on the size of each room as on the amount of exposed wall surface, taking into account its thickness and the material of which it is made; also the size of the windows, the floor area when there is no heated room below, and ceiling area when there is no heated room above. The number of heat units given out for each degree difference in temperature between the radiator and the room temperature is known; so, having decided at what temperature the radiators are to work in cold weather, you can calculate their size.

Choice of Pipes. The most difficult part of the task is to calculate the correct pipe sizes for the mains and branches. The problem is to decide what sized pipe will be required to convey the necessary number of pounds of water per hour to each of the radiators, taking into account the resistance that will be offered to the flow of the water by friction with the pipe and in passing round the necessary bends and through the valves on its journey. If the pipe size selected is too small, the frictional resistance will be too high, with the result that insufficient hot water reaches the radiator to heat it properly. If, on the other hand, the pipe size is too large, too much water reaches the radiator, to the disadvantage of the other radiators in the system. It is very common to find that some of the radiators get hot, while others will not do so. This can generally be adjusted by using valves to regulate the flow through the various branches, but it is a long and costly process.

The real test of a well-designed apparatus is to see if all the radiators get hot with all the valves wide open; and if this test were applied a great number of heating systems would be found wanting. It is, however, quite possible to design an apparatus to fulfil this requirement, and it is a double advantage to the purchaser, because not only does the system work at a lower resistance, which means a saving in fuel, but the calculated cost is usually lower than that of a badly designed apparatus.

Fixing Pipes. In fixing the main pipes, care must be taken to arrange for a slight rise in them on the way out from the boiler, with a corresponding fall on the way back. To put this in the language of a hot-water engineer, you must avoid "dips" in the pipes. If a dip occurs, air, which is always given off where water is heated, will collect in the pipe just before the dip, and will cut off the circulation of the water. It is for the same reason that air-taps are always fixed at the top of radiators, and at the ends of branch mains, where they turn back to the boiler. These taps are occasionally opened, and a little air comes out before water. Sometimes air-pipes are carried up to a point above the level of the cold-water feed cistern, and through them the air passes out into the atmosphere whenever any is given off by the water. By this arrangement the system is kept continually "vented."

The Damper Regulator. Another very useful piece of apparatus which should always be used is called a *damper regulator*. It is fixed on the boiler, and a part of it projects into the heated water. If the water gets too hot, the regulator automatically closes the draught door below the fire-bars, and opens a check-draught door in the flue. This quickly has the effect of cooling the water

down, by retarding the rate of combustion in the fire. In the same way it increases the rate of combustion if the water begins to get cool. The better forms of this fitting maintain a wonderfully even temperature in the system. The apparatus can be adjusted to work at any desired temperature, thus ensuring a very even heating effect, and also securing a considerable economy in fuel.

Advantages of Hot-water Systems. The great advantage of the hot-water heating system is the economy in fuel. The modern types of heating boiler have an efficiency varying from 60 to 75 per cent., and it is no uncommon thing to find that it is possible to keep four rooms continually warm with the same amount of fuel as is required for warming one room with an ordinary open fire. It does away with cold draughts. If a house is warmed throughout, there is not the same necessity for keeping doors shut, and the air that slowly enters a room through the doorway, being warmed air, is not noticed. It adds considerably to the comfort of a dwelling if there are outlets in each room; such an outlet is usually found in the chimneys. Warmed air escapes up these, and so the necessary air change is secured.

Ventilating Radiators. Ventilating radiators are also made. They are constructed with a chamber for warming air, which is drawn in through the outside walls. The radiating surface, not being at a very high temperature, does not have such a bad effect on the incoming air as a ventilating grate or stove.

With this system it is easily possible to keep the house continually warmed, as the fire, even in small boilers, can be kept in all night.

The disadvantages are that it has a tendency to warm the air too much, and the radiators, not being at high temperature, are, in spite of their name, not good sources of radiant heat.

An Almost Ideal Combination. With a hot-water heating apparatus in combination with an open fire we get a nearly perfect heating and ventilating apparatus. The radiant heat is supplied by the fire, which also causes the air movement. The ventilating radiators supply the air at a comfortable temperature, and the air can be prevented from becoming too dry by humidifying pans, which can be fixed on the top of the radiators. Nothing can be more pleasant than a wood-log fire in a room heated with ventilating radiators, and no other arrangement approaches more closely to the physiological requirements.

There are other systems of central heating, which include high-pressure heating, steam heating, and hot-air heating, but none can compare with the hot-water system for warming houses.

Hot Water and its Storage. In these days a good supply of hot water is considered essential, even in houses of quite a humble character. This is usually arranged in connection with a boiler, heated by the kitchen fire, though in larger establishments an independent boiler is provided for heating water only. Flow and return mains are connected to the boiler in the same way as described in the hot-water system of warming. The circulation is also set up in the same way.

It is also essential in any such system to provide some means of storing hot water. The boiler, if heated by a kitchen fire, is necessarily of small capacity; and if the water in the boiler and the circulating mains was all that the system contained, it would be at a very high temperature, but would be very small in bulk. Such a system would very quickly be emptied when water was drawn off from any of the taps. In every system, therefore, a tank or cylinder, capable of holding a considerably larger bulk of water than the boiler, must be provided, but the size of this receptacle must be properly proportioned to the power of the boiler and the fire that heats it. The tank, when used, is usually fixed above the highest point at which it is required to draw off water, while a cylinder is fixed usually close to the boiler itself, and all draw-off taps are taken from the flow pipe above the cylinder.

The *tank system* [13] is the older form. Its chief drawback is that, in the event of the cold-water supply failing, the tank may be completely emptied by water being drawn off from taps, so that only the water in the boiler is left. This may be quickly converted into steam and evaporated, and the boiler left empty. Should this occur, the boiler is liable to become red hot, and to be damaged; and if the water supply is resumed while it is in this condition an explosion may occur owing to the sudden generation of steam.

The Boiler. The general arrangements of this system are as follow: the boiler is usually in the form of a *boot boiler* [8] or a *saddle boiler* [7], and is generally of iron, sometimes of copper. It is set at the back of the kitchen range. The flow pipe is taken from the top of the boiler, and it should be arranged so that its end does not project below the internal surface of the boiler. If it does so project, an air chamber is formed in the top of the boiler, which, though it may not interfere with circulation, results often in somewhat alarming noises in the boiler. The boiler must be provided with a small manhole to facilitate its examination and cleansing from time to time, and should have fixed to the flow pipe close to it a safety valve, properly weighted, which will allow of any steam generated in the boiler blowing off.

The Circulating Mains. The size of the flow pipe will depend upon the number and character of the taps that are to be supplied by it. It is taken from the boiler by the route that will most easily bring it near the various fittings it is intended to serve, to the tank, and must ascend gradually the whole of the way. The inclination need not be uniform throughout the length, but should never be less than 1 in. in 10 ft., and it is not desirable that pipes should be so nearly horizontal as this if it can be avoided. The reason for this regular rise is to allow the air, which is contained in all water, and which is driven off when it is heated, a free route of escape. If this is not provided, the air may collect in the pipe and impede or stop circulation. The flow pipe may be taken through the bottom of the tank, and is allowed to stand up in it for a considerable distance, or it may be connected through the side at a corresponding level. This is because the cooler water is at the bottom of the tank; and this arrangement ensures that, when a tap is opened, the water drawn from it will be taken from the upper and warmer layer of water and not from the bottom of the tank, with which the inflowing cold supply mingles.

The *return pipe* is taken from the bottom of this tank, and is returned by the easiest route to the boiler; and, like the flow pipe, this should never be quite horizontal, still less should it dip at any point. If it enters the boiler at the top, it must be continued inside the boiler, so as to deliver the water near the bottom, or it may be connected to the boiler by a side connection low down. The

circulation pipe should be of 1 in. diameter at least; and if the capacity of the tank exceeds forty gallons, or if more than four fittings are served, it should be 1¼ in., and for bigger installations even larger.

Branch Pipes. All branch pipes to apparatus, such as sinks, lavatories, baths, etc., are taken from the flow pipe, and it is desirable that all such branches should be as short as possible, for the water in them does not circulate, and therefore becomes cold. When the tap is first opened, all the cold water standing in the pipe must be drawn off before the hot water begins to flow, and it is desirable to reduce the amount of this to a minimum. The usual sizes for branch pipes are, for lavatories, ½ in.; for sinks, ¾ in.; for baths, ¾ in. or 1 in.

Cold-water Supply. This is an essential feature, and allows of water flowing in from the cold-water cistern to replace immediately any drawn off from the system when a tap is opened. The supply must be arranged so that, when water is drawn off, only hot water flows from the tap as long as there is any hot water in the system; but without skilful treatment it may easily happen that cold water will find its way to the tap and mingle with the hot and reduce its temperature. The hot-water tank must be fixed at a lower level than the cold cistern, with which it is in many cases directly connected by a pipe. There is no valve between the two systems, but a screw-down stop valve may be very usefully inserted, to shut off the supply in case of repairs. In order to prevent any chance of hot water working its way up the supply pipe into the cold cistern, this pipe should have a dip in it at least 6 in. deep just before it enters the tank [12]. It may enter the tank through the bottom and be finished with a T-piece to deliver the water horizontally and close to the bottom, or it may enter the cistern at the side close to the bottom, and may then be prolonged inside the cistern and finished with an elbow. The cold-water supply pipe should be 1 in. at least, except for quite small installations.

In some cases a feed cistern [13] is provided to supply the hot-water cistern only. This is connected directly with the tank, and is supplied by water from the main cistern through a ball valve. This effectually prevents any return of hot water to the main cistern, but there must be sufficient capacity in the feed cistern above the cold-water line to accommodate the increase of bulk due to heating the water.

Expansion Pipe. From the top of the tank a pipe is taken, of the same diameter as the flow pipe, and it is continued upwards to a point not less than 2 ft. above the cold-water cistern. In cases where the boiler is 60 ft. or more below the cistern, this height may be increased to 3 ft., and in either case the end of the pipe is bent downwards over the cistern. This pipe serves a double purpose—that of an expansion pipe to allow of the escape of water, and that of a vent pipe to allow of the escape of air. The expansion of water, when heated, has already been referred to, and in such a domestic apparatus may amount to from 2½ per cent. to 3 per cent. of the original bulk. If the system is charged with cold water and heat is applied, expansion will at once begin; and if no outlet is provided at some point it would force an outlet for itself. The water as it expands rises in the expansion pipe, and eventually overflows into the cold-water cistern, so that no waste of water occurs, and this continues till the water has reached its maximum bulk. Normally, the water stands in this pipe at the same level as in the cistern.

The Cylinder System. In this system [11] the vessel for storing hot water is placed near the boiler, and is therefore, owing to the head of water, subjected to a much greater pressure than the tank at the high level. The cylindrical form is therefore selected on account of its strength. The pressure exerted in any case may be calculated by allowing 1 lb. of pressure for every 2 ft. 4 in. of vertical height. The boiler is similar to that used in the tank system, and is connected to the cylinder with a flow and return pipe. The flow pipe should be connected with the cylinder at a point about two-thirds or three-quarters of its height from the bottom, and, if connected at a lower level, should have an internal pipe added to deliver the water heated by the boiler at this high level. The return to the boiler is taken from the bottom of the cylinder to the lower part of the boiler. The cold-water supply may be brought down and connected to the lower level of the cylinder in the same way as is described for the tank, or it may be connected to the return pipe. It should be of ample size, or the flow of water from the draw-off taps, especially those at a high level, may be checked. A full-way stop valve should be provided in this pipe near the cylinder, to facilitate repairs, but there is no other form of valve used. So far, this arrangement corresponds with that of the tank system, except that in this case the boiler and cylinder are very close together; but no draw-off tap is taken from the flow pipe between the boiler and the cylinder. A draw-off cock should, however, be fixed at the lowest point of the return pipe just before it enters the boiler, or in the boiler itself, to facilitate emptying the cylinder and boiler should examination or repairs be required. This should be fitted with a loose handle, which is kept separate from it, to ensure that it is used for no other purpose.

Secondary Circulation. In order to provide the necessary service to the various fittings, a secondary circulation is fitted up from the cylinder. The flow pipe is taken off the top of the cylinder, and is carried up as high as may be necessary to serve the highest fitting in the building to which hot water must be taken. From its highest point the return pipe descends to the cylinder, and is connected to it at a level above that at which the main flow pipe from the boiler delivers hot water into the cylinder. This arrangement secures that only the hottest water in the cylinder is circulated through this pipe. Though the terms *flow* and *return* are applied to this secondary circulation, draw-off taps may be taken from any point in the circuit, as there is no cold-water connection with any part of it. The expansion pipe is taken from the highest point in this secondary circulation to a level above the cold-water cistern, and arranged so as to deliver into it as described for the tank system. As the whole of the taps are connected to the secondary circulation which is above the cylinder, it is impossible that the latter can ever be accidentally emptied.

Conserving the Heat. The efficiency of the system may be considerably increased by surrounding the cylinder, and, when possible, the main pipes, with some non-conducting substance. For the cylinder, a thick layer of silicate cotton may be employed, kept in position by laggings of wood closely fitted and bound with iron or brass bands, which form a very neat finish. For the pipes, if

these are run in pipe casings, they may sometimes be packed in the same manner, or they may be wrapped round with asbestos sheeting. Either material prevents the cooling of the pipes to a very great extent, and tends to maintain the temperature of the water with but little loss.

Cylinder Tank System. This system is sometimes adopted, especially in large installations, and is essentially the same as the cylinder system, with the addition of a storage tank at a level above the highest draw-off. The advantage of this combination is that, with a large body of hot water above the highest tap, there is no danger of the water flowing sluggishly from any of the taps, as happens sometimes in upper floors in the cylinder system, while at the same time there is not the risk ordinarily attending the use of a tank, as the cylinder below renders it impossible to empty the system. But if a large body of water is to be heated and stored, a powerful boiler will be required, and with this system an independent boiler is often useful.

We have considered in some detail the methods of heating ordinary domestic buildings, including the hot-water supply, and must now consider the simpler means of ventilating such buildings, referring afterwards in more general terms to the more complicated systems in use in larger structures.

VENTILATION

The object of domestic and general ventilation is to secure an air change, and to keep the air in motion, the latter function being a valuable means of mixing up the air and preventing the accumulation of saturated air and air containing too much CO_2 in the part of the room where the occupants are. As previously stated, the investigations of Dr. Leonard Hill point conclusively to the fact that not so much fresh air need be supplied as was formerly thought to be necessary.

It will have been noticed that many of the ordinary appliances intended for heating are also valuable as ventilating agents. The open fire, ventilating grates, stoves, ventilating radiators, would all be included in a list of ventilating appliances in the system known as natural ventilation. There are several other appliances coming in the same class to which reference will now be made,

Ventilating Sash Windows. It is not always necessary to provide special openings for this purpose, as many modern sash windows are constructed to act as ventilating inlets, and answer admirably if suitably placed. This is done by making the bottom rail of the bottom sash of extra depth, and providing a deep bead above the sill in the inside [**14**]. The lower sash of such a window may be raised two or three inches without being lifted above this bead, so that air is not admitted at the sill level; but the top rail of the lower sash will be raised, and an opening formed at this point between the lower and upper sash, at which air can freely enter, which will be delivered in the room at a considerable height, generally above the level of the heads of the occupants. Such an arrangement will have less tendency to produce a perceptible draught than having the window closed and letting air force its way in between the sashes and the frame, for it is important to remember that the larger the opening, the lower will be the velocity with which any given volume of air will pass through it in a given time. When, however, there is a considerable difference between the internal and external temperature, if cold air is admitted it is almost impossible, even with this arrangement, to avoid the sensation of draught.

Special Ventilating Openings. If windows are not made use of, special inlets may be made in the external walls, and provided with fixed gratings externally, and with some form of movable grating or valve internally. Such an opening should not pass straight through the wall from its outer to its inner face, but should be bent upwards in the thickness of the wall.

The external gratings may be of iron or terra-cotta, and are intended to prevent birds nesting in the openings. The internal surface of the flue itself should be smooth, without sharp angles, and may be formed in Portland cement and sand, trowelled, or may be lined with a metal tube. The internal grating may be what is termed a *hit-and-miss grating* [**15**], which consists of two metal plates perforated in identical manner, which allows the passage of air through both sets of openings when they correspond in position; but when one of them is shifted sideways the solid parts of one grating lie over the openings of the other, and either wholly or partially check the passage of air. Many forms of valved gratings are employed. In some a kind of hopper head is allowed to fall forward when air is to be admitted, and is raised again when it is to be closed [**16**]. In others a diaphragm is fixed on a pivot, which can be turned so as to open or close the passage as desired.

Tobin Tubes. Another form of inlet is the apparatus known as a Tobin tube [**18**]. This consists of a short vertical tube, generally about 6 to 7 ft. high, which may readily be inserted in an existing building. It is usually formed of wood, and, if so, must be well framed and glued up, so that the joints are perfectly air-tight. It may have a metal lining, which is generally of zinc. The horizontal sectional area will vary according to the cubical capacity of the room to be ventilated; but the sectional area of the tube, or, if there are several in one room, their united area, should be calculated so as to give, at the very least, 25 sq. in. for every 1000 cubic ft. of air space. The lower end is connected with the external air, and protected by a grating. Such tubes may sometimes be usefully placed against an internal wall when an air-trunk can be taken under the floor or in its thickness to such a position. The upper end is usually open, but covered with a fine grating, and the air is delivered with an upward tendency. Such a tube may be fitted with a diaphragm in its course, so that the opening may be either closed or wholly or partially opened.

It will be noticed that the apparatus described under the last three headings all allow air to pass into a room from the outside. Although they are very useful when the external air is above 55° F., they cannot be used if the temperature falls much lower, and they are consequently constructed so that they can be closed.

Positions of Ventilating Openings. There is much difference of opinion as to the best positions for inlets and outlets, but the general tendency is to place the inlets high up on the wall and the outlets low down, so that expired air and the products of combustion from lamps and gas-burners, as they are produced, are withdrawn from the lower parts of the room. It is often advocated that the two openings should be at different levels in the same side of the room, and that this arrangement tends to promote the most complete circulation of air, while others advocate placing inlets

and outlets in opposite walls. Much will depend on whether there is only one inlet or outlet in a room, or if there be more than one. In the latter case, it should be possible to avoid any stagnation of air in any part of the room when the inlets and outlets are placed in opposite walls.

An outlet is not infrequently formed into the smoke flue of a fireplace, near the ceiling level, which must be provided with a mica valve, similar to that used in a fresh-air inlet. This will allow air to pass through it from the room into the flue, but will prevent air and smoke passing into the room from the flue.

Ventilating gas-burners have been much employed for certain classes of buildings, and less frequently for private houses. In these the heat generated by the combustion of the gas is taken advantage of to create a current of air in a specially arranged outlet tube, which will carry off the vitiated and heated air that collects in the upper part of a room when no other means of ventilation are provided.

Ventilating Domestic Offices. Before leaving the subject of natural ventilation, it is advisable to point out that it is necessary to ventilate not only rooms used by human beings, but rooms used for preparing and storing human food, and rooms which contain sanitary conveniences. In the case of the latter, it is very undesirable that air should be drawn from them into other parts of the building, though this is usually difficult to prevent. Such chambers are rarely heated, and tend to form a source from which cold air may readily be drawn, as in many cases some permanent opening direct to the external air is insisted upon. When such chambers are heated, they should be kept at a higher temperature than that of adjoining passages and rooms, the result of which will be that any movement of air that takes place will be into the chamber rather than out of it.

Prevention of Stagnation. Ventilation must also be provided in all positions in which air would tend to become stagnant, especially if there is at the same time, any tendency to moisture and heat. In the case of a store-room or cupboard having no external window, it often suffices to bore two sets of holes, about 2 in. in diameter, one set near the top of the door and the other a few inches above the floor level.

The space under the lowest floor of a building, if the floor is not laid solidly on concrete, is a position in which the importance of ventilation is paramount. If none is provided, the air becomes stagnant, and the timbers are liable to decay from the attack of fungous growths and from dry rot. It is therefore essential that openings be provided in external walls [17], and in any cross-walls such as will allow of a free circulation of air under all parts of such a floor. Further, as already pointed out [on page 2725], it is important that all hollow spaces formed when walls are built in two thicknesses, and when dry areas are provided, should be efficiently ventilated.

Mechanical Ventilation. The other system of ventilation, in which some mechanical means is adopted to secure the necessary air change, is usually employed in large buildings and institutions. In it there are two systems of ducts—those which deliver the air to various rooms, and those which carry the used-up air away. The motive force employed to move the air is generally a fan driven by an electric motor. The mechanical power is employed usually in one of two ways. It either forces the air into the building, when it is known as the *Plenum system*, or it extracts the air from the building, when it is known as the *Extractum system*. In many instances the two systems are combined, in which case fans are used to draw air in, and also to draw it out.

In both systems the fresh air is brought in through a main duct, where it can be heated, filtered, and moistened, and then distributed through branch ducts into the various rooms to be ventilated.

In the "Plenum" system it is not necessary to treat the ducts through which the air leaves the building in the same way. Each room may have its own outlet directly into the open, care being taken that any wind pressure which will occur on the side of the building cannot force its way in through the outlets, or prevent air from coming out. To get over this difficulty it is the usual practice to form vertical ducts in the internal walls, carried right up above the roof level, and protected from down-draught.

In the "Extractum" system, in which the air is drawn out, a similar arrangement for the outlet ducts must be provided as for the inlet ducts; they must all unite with one main extraction duct, in which the extract fan is fixed.

In smaller systems, the extraction is sometimes secured by means of heat. Large gas-rings, heating coils, and even furnaces are sometimes used. The extract ducts are led to the point where heat is applied, and a vertical flue is carried up above the roof level, closed at the top, but provided with louvre openings on all four sides into the outside air. The application of heat at this point, where it cannot assist in warming the building, is recognised as wasteful, and the method has been largely superseded by the use of electric fans, which can be operated at a very low cost.

Before leaving the subject, reference should be made to the use of an independent electric fan working within a room and not in a duct connected to the outside air. Dr. Hill's experiment has clearly shown the utility of such a fan; and it can be strongly recommended as a means of maintaining a movement of the air within a room. The only precaution necessary is to see that it does not blow directly on to the occupants.

LIGHTING

The adequate lighting of all parts of a building is a matter of the utmost importance to its comfortable use. The lighting by day is secured by the provision of openings of sufficient size and suitably placed to admit daylight to all parts; and the success of this treatment will somewhat depend on the adequacy of the areas from which light is derived. In towns these are to some extent regulated by Building Acts or by-laws, which regulate the height of buildings in streets of various widths, and the extent of open space that must be provided in the rear of such buildings. These regulations are mainly directed to the provision of spaces not wholly inadequate, into which the windows for lighting various rooms may open, and from which both light and air may be obtained. In many cases regulations are also made as to the size of internal courts provided as areas for light. In the case of London, in buildings erected in newly laid-out streets, the provisions are intended to secure that if a line is drawn from the ground level of a building on one side of a street to the eaves or parapet of the opposite building, the angle it makes with the horizon shall not exceed 45°. In the case of a window obtaining light from a court, the line drawn from the sill to the eaves or parapet of the opposite wall must not make a greater angle than 62½°; and in the case of the open area at the back, while the

angle varies somewhat according to the actual height, the conditions secured are rather better than those in an internal court. These are general rules, modified in the case of buildings irregular in plan, and in the case of buildings laid out in old streets or replacing older buildings destroyed or taken down. All such provisions must be carefully observed, and represent the minimum requirements for towns, and, wherever possible, more favourable conditions should be provided. In particular, an effort should be made to secure that in a domestic building every habitable room should receive at some time in the day not merely daylight, but sunshine, which is of the utmost importance from the point of view of health.

Darkness, as well as stagnation of air, favours the development of many noxious germs, and it is important, therefore, that not only the habitable rooms but the corridors, staircases, and the various offices of such buildings should be adequately lighted in every part. In many buildings the conditions governing the place may make it difficult or even impossible to provide for the complete lighting of every part, but it is a consummation to be aimed at, and approached as nearly as may be.

Artificial Lighting. It is absolutely essential, in addition to securing an adequate provision of daylight, to provide some means of artificial illumination, by means of which the various occupations of life may be continued after daylight has failed. At no time has the means of doing so been so complete and efficient as at the present day. Immense strides have been made within the last thirty years, due to the introduction of electricity as an illuminant suitable for domestic lighting. Not only is the light itself admirable from many points of view, but it has stimulated the inventive powers of those interested in gas-lighting, and led indirectly to great improvements in this branch of lighting also.

It is not necessary to do more than refer to the older forms of illuminant—candles and oil lamps—as they do not involve any special preparation in the course of the construction of a building, and, in its finishing, only require the provision in some cases of suitable brackets or holders for the lights. But it may be pointed out that lamps certainly have shared in the general improvement, and that both candles and lamps are in many respects pleasant forms of illumination, and must, even in these days, be relied upon by a very large class of householder—by those who live in districts not served by any public gas or electric company, and whose requirements are not sufficient to warrant the establishment of a generating plant for either illuminant.

The drawbacks to their use are mainly expense and the trouble of daily attention, and the risk of damage to carpets and furniture, often due to carrying about such movable lights. Such means of illumination are, however, sometimes used to supplement both gas and electric light installations, which are not always carried into every part of a building.

In the case of buildings situated so that there is no public supply of gas or electricity available, it is possible, if the circumstances warrant the outlay, to establish a private generating station for either gas or electricity, but it is not possible to deal in this article with the details of such installations. It is, however, comparatively rare to find private installations for generating coal-gas. Such an apparatus requires skilled attention, and it would be possible to supply gas economically only in the case of a large mansion.

Acetylene Gas. *Acetylene gas* is another form of illuminant that in recent years has come largely into use for such moderate installations; it gives an exceedingly good light, and is, as a rule, less expensive than a gas installation. For an equal amount of illumination the cost is usually estimated as equivalent to that of gas supplied at from 3s. to 3s. 6d. per 1000 cubic ft. The principal drawback to its use is the extremely unpleasant odour that is apparent if the combustion is not absolutely complete.

The great advantage of such an installation is that it does not require any constant or highly skilled attention, but may be operated by a gardener, and will not, at the outside, take more than a few minutes' attention daily. The gas and its installation are dealt with, in detail, on pages 5540 and 5541.

From the holder the supply pipe to the house is taken. A governor to regulate the pressure, which is otherwise variable, is usefully added, and the pipe first descends to a low level, from which it may rise regularly to the house. At the lowest level a small tube or container is fixed to catch any water flowing back from the service pipe, with a tap by which it may be emptied. The supply pipe is usually iron; copper must not be used for supply pipes or in fittings which will come in contact with the gas, as an explosive compound is liable to be formed.

Service Pipes. The service pipes are arranged as for ordinary gas supply, as already described [page 5369], but the consumption of gas is very much less, and somewhat smaller pipes may be employed. Great care is required in making all joints so as to prevent any escape of the gas, which has a sickly, unpleasant smell, and is, as already stated, highly inflammable. It is usually best to employ steam-piping rather than ordinary gas-piping, and to see that the screwed joints are sound and made with the smallest possible amount of white lead, as joints that would be perfectly tight when ordinary coal-gas is employed will permit the escape of acetylene.

Acetylene Gas Fittings. The fittings used with acetylene gas may be high-class gasfittings or special fittings, the important point being to ensure absolute soundness in the joints and cocks, to prevent the smallest escape of gas. The burners are of special form [see page 5541]. The holes for delivering gas are very minute, and are arranged so that the gas jets from two holes impinge and produce a flat flame. The burners are arranged on the Bunsen system, so that atmospheric air is mixed with the gas before combustion; and the most recent form of burner, introduced by Messrs. Bray & Co., overcomes a difficulty that when a gas flame was turned down the burner was apt to become carbonised, so that it was difficult to use a burner except at full power.

The most usual size of burners are the following:

Burner consuming $\frac{1}{3}$ cubic ft. per hour, giving a light of 6·2 candles.

Burner consuming $\frac{1}{2}$ cubic ft. per hour, giving a light of 17·5 candles.

Burner consuming $\frac{5}{8}$ cubic ft. per hour, giving a light of 35 candles.

Hydrogen Gas Fittings. The fittings used for ordinary coal or hydrogen gas were briefly referred to in the article on gasfitting [page 5369]. It is, perhaps, hardly necessary to point out that so far as the form of the fitting and its artistic treatment is concerned there is room for almost infinite variety, and such matters are regulated by individual taste, the money available, and the character

of the building in which they are to be placed. But whether the fitting be a bracket or a pendant, fixed or movable, of iron, brass, or copper, plain or elaborate, its main purpose is to provide at a suitable point in some room or hall a burner which will supply gas at a point where illumination is required. The number and disposition of lights, whatever the illuminant, require careful consideration, and depend greatly on the use to be made of the particular chamber. The following table gives the appropriate amount of lighting that is usually considered requisite for various classes of building, but this is subject to variation in individual cases, and, in particular, if the height of the fitting is varied from the normal position.

	Per 1000 sq. ft. area,
County district roads	¼ candle power
Towns (urban)	4 ,,
Cities and boroughs	10 ,,
Dwelling-houses (principal room)	250 ,,
Cottages (principal room)	150 ,,
Hospitals	50 to 100 ,,
Schools	300 ,,
Churches and chapels	300 ,,

This is a matter of considerable importance, for it must be remembered that the illuminating power of any illuminant as affecting any object varies, not according to the distance that separates them, but according to the square of the distance; and if, therefore, lights are fixed at an unusually high level, they must be much more powerful to produce the same effect at the floor level.

Gas-burners. The ordinary gas-burner is arranged so as to produce a flat flame. The orifice is formed in a very refractory substance, *steatite*, mounted in a brass holder provided with a screw, by which it can be attached to any form of bracket or pendant. The commonest form is known as a *bat's-wing* burner, and is formed with a thin slit in a cone-like termination from which the gas issues. The *slit union* is somewhat similar, but the termination is spherical. The *union jet* has two small circular perforations, from which the jets impinge and form a flat, slightly cup-shaped flame. None of these ordinary forms of burners secure the complete combustion of the gas or the highest amount of illumination from that which is consumed, and they require fairly frequent renewal in order to get satisfactory results, but they are in all cases inexpensive, and easily fixed and renewed by the householder himself, without calling in the gasfitter. Such burners are usually protected by glass or china globes; and if placed within 3 ft. of a ceiling or of any woodwork there should be a talc top fixed over the globe, or a glass or metal bell fixed over the light. In public institutions the flame is often protected by a wire globe secured to the fitting, and this is a very useful precaution in the case of a swing bracket which might be swung into contact with any inflammable material.

Improved Burners. An improvement on the simple burner is one fitted with an *economiser*, which is really a second burner of greater capacity, placed over the inner one, producing a larger flame without a greater supply of gas, and securing more complete combustion. Other burners are fitted with some arrangement of governor, by which the pressure at the burner is regulated, though the pressure in the service pipe is subject to fluctuation. There are several varieties of such burner on the market. The *Argand burner* is one arranged to produce a circular flame similar to that produced from the circular wick of an oil-lamp. The burner is circular in form, with an air space in the centre, and a series of small apertures are formed from which the gas issues, so that a ring of flame is produced. Air has access to the middle part of the flame, which is enclosed with a wide glass chimney.

Incandescent Burners. The most striking innovation in the use of gas in recent years has been the introduction of what are known as *incandescent* burners, which have, to a great extent, revolutionised gas-lighting. The best known form of burner for the domestic purpose is the Welsbach C. burner. This consists of a burner producing a hot flame which impinges on a mantle suspended directly over it, and which is heated and maintained by the flame in an incandescent condition, producing a brilliant illuminating surface. The mantles are impregnated with *thorium*, and are somewhat delicate, and their life is uncertain. When used in this way the gas may be mixed with atmospheric air, as in an ordinary Bunsen burner, and used to the greatest advantage, with the approximate result that with a reduction of 50 per cent. in gas consumption the illuminating power is doubled. The burner is also somewhat expensive in the first case, and the maintenance of mantles is a considerable item, but for equal illumination there is, in spite of this outlay, a very great economy in the use of incandescent lighting, as compared with other forms, accompanied by a more complete gas consumption.

An inverted incandescent burner may now be obtained, in which all the metal parts of the fitting are above the mantle, which therefore throws no shadow on a table over which it is placed, and in this respect attains one of the great advantages secured by most electric lamps.

Electric Lighting. Electric lighting is dealt with in detail on pages 2339 and 2467. Its advantages are:

The light, being turned on and off by the movement of a switch, conduces greatly to the economical use of the light; the absence of heat and all products of combustion, which in the case of all forms of gas-lighting contribute to the vitiation of the atmosphere of rooms, the gradual destruction of decorations, and the blackening of ceilings; the safety from fire where the installation is well executed, which is also effected by the absence of all unprotected lights, and the absence of all use of matches.

To set against this is the increased cost of electricty over gas for an equal amount of lighting, but this is a matter that depends very much upon the way in which the installation is planned out and used. Very great economies may result from the careful arrangements of fittings and proper provisions for turning on and off the lights in a group separately or in small groups. It should also be borne in mind that while the cost per candle-power is higher in the case of electrlcity, as compared with gas, it does not follow that the cost per fitting is correspondingly as high, at any rate when comparison is made with an ordinary gas-burner, as a very much more brilliant light is often obtained, for which a higher price may properly be expected. When the great saving in the cost of redecorating work is taken into account, and a little care is taken not to burn light wastefully, it is found in many cases that the cost of lighting a house throughout by electricity is not very greatly above that of lighting it by gas. Electricity is more readily produced than coal-gas in small quantities, and is eminently suited for private installations of moderate size, but the attention of a skilled mechanic is necessary, so that it is not adapted for work of a very small character.

Strand, Concentric, and Three-Core Cables. Conductors and Insulation. Making, Covering, and Testing. Joining. Systems of Laying.

CABLE MAKING AND LAYING

For the distribution of electricity in large quantities, cables are in general use. The electrical cable is an insulated or separated artificial path or track along which electricity will flow readily. The path is a metal core, known as the *conductor*, and the material which separates it from the surrounding objects is known as the *insulation*. Copper has been found to conduct better than most other substances, hence we find the conductor in nearly all cables made of a copper-wire rope or strand. The insulation is a coating of a material which will not allow electricity to pass through, or along it, except under very great pressure; therefore, when this material is placed round the core, the current flowing through the conductor is entirely separated from objects around it and is consequently under control.

Insulation. Insulations fall naturally into two classes: (1) *hygroscopic*, or moisture absorbing; and (2) *non-hygroscopic*, or moisture resisting. The more common of the first class are jute and paper, and of the second, vulcanised indiarubber, gutta-percha, and bitumen.

The first successful experiment in which a continuously insulated cable was used was in 1812, when Baron Schilling exploded a mine by electricity conveyed by a wire insulated with indiarubber, and laid across the River Neva. In 1815, or 1816, Ronalds carried out some experiments in telegraphy, and, in addition to an overhead wire, which was suspended by silk threads hanging from wooden frames, he had one, a little less than a furlong in length, underground. This was drawn through glass tubes, the separate lengths of which were joined together by small glass sleeves placed over the joints and fastened in position with wax. The glass tubes containing the wire were then placed in a wooden trough and covered over with pitch. This method of insulation was not very successful, as the glass was very liable to break and leave the wire uninsulated. The stranding of wires was introduced when large sectional area and flexibility were required. In 1837, a line was laid in London in which the wires were covered with cotton steeped in resinous compound, and then laid in grooves cut in baulks of wood. The insulation of these wires soon gave way, because the cotton decomposed and left the wires practically bare. The dampness which caused the decomposition also acted as a conductor, and allowed the electricity to escape.

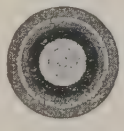
In the following year a line was laid from Paddington to Slough. In this instance the wood was replaced by iron pipes; but the line had the same fate as its predecessor, and an overhead system was substituted. In 1845, a proposal made by Wheatstone and Cook to enclose the cotton-covered wires in lead tubes, was a step in the right direction, and a patent was taken out in the same year for lead-covered wires. Cables covered with lead gave much better results than previous ones, and about this time a new insulation was discovered in gutta-percha, Faraday being one of the men who found that it was a good insulator. The first wires insulated with gutta-percha were laid in London in cast-iron pipes in the year 1849.

Conductors. The chief conductor nowadays is the copper-wire strand or rope. The separate strands which form this rope are usually tinned in order to keep their surfaces clean, because tarnished copper is not so good a conductor as clean copper. The most commonly used moisture-resisting insulators now in use are indiarubber, bitumen, and gutta-percha, and the principal moisture-absorbing, jute and paper. The india-rubber insulation is laid on in two kinds. The first kind, which touches the copper strand, is pure and free from sulphur, because sulphur tarnishes metals. The second kind is a compounded rubber containing sulphur. This will vulcanise and become firm and resilient. The bitumen is first thoroughly refined and then mixed with sulphur and other chemicals, and vulcanised like the second layer of rubber. Before the bitumen is applied, a layer of thin rubber-coated cotton tape or paper is wound round the strand to prevent the sulphur in the bitumen tarnishing the copper. Gutta-percha is used in a flexible state chiefly for low-pressure work, such as telegraphic insulations.

The paper used for insulating purposes is strong manilla paper soaked in resinous compound. The jute is usually applied in the form of a braid impregnated with oily compound.

So far, mention has been made only of the two essentials in a cable—namely, the conductor and the insulation; but it is not often that one meets with a cable in use made only of these two. Nearly every cable has some extra coverings, either to make the insulation perfectly waterproof, or to give the cable some mechanical protection. Lead sheathing, steel tapes, galvanised iron wires, and jute braid are extensively used for these purposes, as will be shown in the following descriptions of cable-making.

Varieties of Cables. Of the several kinds of electric lighting and power cables made, the most widely used are the "Single," the "Concentric," the "Twin," the "Triple concentric," and the "Three-core." The *single* cable [1] consists of a central copper strand, a layer of insulating material, a covering of braid, and a sheathing of protective armouring.



1. STRAND CABLE

The process of making a "single" indiarubber insulated cable begins with the conductor. The copper wire for this purpose has usually a tin coating, and comes from the makers, when not drawn at the cable works, in hanks. These hanks are sorted into the various sizes of wire, and the desired size for the cable about to be made is chosen, and thoroughly cleaned to remove all traces of tarnish, dirt, and grease. After being cleaned and examined, single lengths of the copper wire are wound on separate small metal drums or bobbins, which fit round the circular frame of the stranding machine. The number of drums used at one time, and the size of wire wound upon them, depend upon the amount of current the finished cable will have to conduct. A large number, of a large size, are required for a large current. When the drums are in position there is passed through the centre of the machine a central wire to which the ends of all the

wires on the small drums are attached. As this central wire is drawn along the machine is set in motion and the frame containing the drums rotates in such a manner that it twists or strands all the other wires round the central one, so as to convert them into a wire rope or strand [see page 2248].

Applying the Insulator. If the conductor is free from grit and grease after this operation, it is ready to receive its covering of insulation. For this purpose, if it is a small-sized cable, it is taken to the longitudinal machine, which consists of a long, raised bed, at each end of which there is a pair of grooved rollers. Rolls of narrow indiarubber strip are placed before each pair of rollers, the first lot being pure, and the second one compound indiarubber. As the end of the conductor is brought up to the first pair of rollers, the ends of two strips of pure rubber are placed about it, one on top and one below; so that when it comes out at the back of the grooves the indiarubber strips are pressed round in the form of a complete covering, with a firmly-pressed longitudinal joint at each side. Although this joint is made only by pressure, yet if the surfaces of the edges of the strips are perfectly clean, it is thoroughly sound. On approaching the second rollers, two strips of compound rubber are applied in a similar manner, so that when the conductor finally passes out of the machine, it is completely covered with two layers of indiarubber.

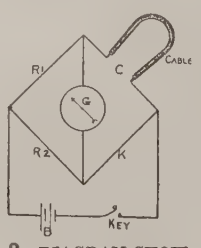
If the cable is of large size, the two kinds of indiarubber are applied by the lapping machine, which covers the conductor by spirally wrapping the indiarubber strips round it instead of pressing them on as at the longitudinal machine. The wrapping of large cables is preferred because the pressure given by the longitudinal machine has not been found satisfactory for the greater thickness of insulation required by them. The separate layers of strips are wrapped in reverse spiral so as to prevent, as far as may be, the possibility of a weak spot in each of two strips, occurring right through the insulation at one place. The thickness of the rubber coating is decided by the considerations of the pressure and disruptive strain that the insulation will have to withstand.

The Indiarubber Covering. When the requisite thickness of indiarubber has been applied, the cable is given a wrapping of indiarubber-covered cotton tape, at the taping machine. This is to add firmness to the covering of indiarubber, which, up to this time, is a plastic substance, of the consistency of stiff dough. In this state it can be easily moulded into any desired shape, and will stick in the shape it is formed. This, of course, is very convenient while the indiarubber is being pressed or wrapped on the conductor, but before the armouring materials are applied over the insulation, it is necessary that it should be firmer and more resilient. With the object of giving these properties to the substance it is taken to the vulcanising house. This is a room containing large, hollow, cylindrical, iron pans to which the necessary pipes, taps, valves, etc., are attached, so that steam may be let in or out as desired. In this room the cable is placed inside one of the pans, after being wound on the drum made especially for the purpose. The pan is closed up by a steam-tight door, and the steam turned on until a certain pressure is reached. This pressure is kept up for a certain time, until the indiarubber is properly vulcanised. The pressure and time of vulcanisation depend upon the quality and thickness of the rubber applied. When the steam in the pan has been let off, and the cable taken out and cooled, it will be found that the outer layer of indiarubber has acquired the desired properties of firmness and resiliency. The acquisition of these properties is chiefly due to the indiarubber containing as one of its ingredients sulphur, which is a vulcanising agent, and which, under the action of steam pressure, chemically combines with the other ingredients and gives the springiness so characteristic of all indiarubber goods. The full chemical action which takes place is not thoroughly understood even in indiarubber manufactures. During the whole process of applying and vulcanising the rubber great care is taken that the surface is quite clean and free from grease of any kind, as the successful manufacture of vulcanised indiarubber cables greatly depends upon the careful handling of the indiarubber.

The cable is now completed as far as its essentials are concerned—it has its conductor and its finished insulation; therefore, before any further coverings are added, either for protection against dampness or mechanical injury, it is taken to the test-house to be tested. Here the cable undergoes a rough test under water, to see that its insulation is sound. A second and more careful test is given when the cable is complete, details of which process will be given later.

Braiding the Cable. If, after the rough test, the insulation is found satisfactory, the cable is allowed to dry, and is then taken to the braiding machine to be covered with a stout jute braid. This braid is moisture-absorbing, and in order to prevent it from rotting, it must be protected from damp. For this purpose the cable covered with braid is passed through the serving tanks, which contain a hot compound, composed chiefly of paraffin wax, and similar substances. The coating of compound on the braid as it comes out of the tanks, besides being damp resisting, is also an insulator, and therefore adds a little to the better insulation of the finished cable. Since indiarubber is a waterproof material, it is not necessary to cover the cable with a lead sheathing, although one is sometimes put on for mechanical protection. The more common method of protecting indiarubber insulated cables against mechanical injury is by encasing them with galvanised iron wires or steel tapes. The wires are stranded over the jute braid by the stranding machine, and the steel tapes are wrapped on by the steel taping machine. Although the iron wires are galvanised as a protection against rust, yet a jute braiding is often applied on the outside of them as a further safeguard.

Testing the Cable. The cable is now ready for its final test, and for this purpose it is taken to the test-house, placed in tanks of water, and allowed to remain there for about twenty-four hours. The testing operation is very important, and takes a day or two to complete. The chief tests made by the makers are those of the conductor, the insulation resistance, and the capacity of the cable.



2. DIAGRAM SHOWING CABLE TESTING

The test of the conductor is usually made by comparing its resistance with that of a known resistance. The comparison may be rapidly made by an instrument known as the Wheatstone bridge [see also page 759]. A simplified diagram of the connections for the comparison is shown in **2.**

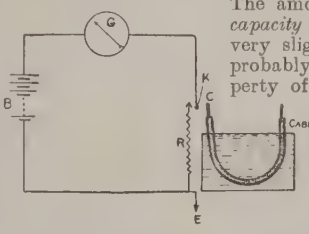
The proportion of the resistance through R1 and R2 is the same as that through C and K when the current passing round the arms causes no deflection in the galvanometer G. R1 and R2 may be read off the bridge scale, and K is a known resistance; therefore the resistance of the conductor under test is easily found from the formula

$$\frac{R1}{R2} = \frac{C}{K} \text{ or } R1 \times K = R2 \times C.$$

Suppose the proportion of R1 and R2 is 2 1, and the known resistance equals 5 units; then from the second formula the cable will have a resistance of 2×5, or 10 units. Another method of testing the conductor is by the metre bridge, the principle of which is somewhat similar.

The Water Test. The test for the insulation is made after the cable has been in water, at a constant temperature, for twenty-four hours. With the cable still in water, the insulation resistance is tested by a method of comparison. The leakage current through the insulation is compared, by means of a galvanometer, with the flow of current through a known high resistance, when the same battery power is applied. The galvanometer is an instrument in which there is a sensitive needle, placed over a graduated circular scale, and surrounded by a coil of wire. This is its simplest form [see page 368].

As the current passes through the galvanometer, the needle is deflected through a certain angle. The comparison, in its simplest form, is made thus: Suppose a circuit is made up of a battery, a galvanometer, and a length of wire. After the current has passed round the circuit for a short time the galvanometer needle will remain stationary at a certain deflection from its original position. If the wire is now taken out, and another one of equal length, but of different substance, put in its place, the galvanometer needle, when the current is next sent round the circuit, will come to rest at a deflection different from the one in the first instance. In both these circuits the battery, the galvanometer, and the length of the wire are the same; the only difference is the substance of the wires, therefore any change in the current can be due only to this alteration. Now the current in a circuit is approximately equal to the electromotive force sent out by the battery, divided by the resistance offered to this force by the wires or other substances in the circuit. If the electromotive force is represented by E, the resistance by R, and the current by C, then $C = \frac{E}{R}$. Applying this formula to both instances above, we see that E is the same in both, but C, as shown by the deflection of the needle, is different; therefore the resistance must have altered in inverse proportion to the current. A numerical example will make this clear. Suppose the battery sends out a force of 6 units and gives a deflection, in the first instance, of, say, 30°, and in the second of 20°. Then since the current is proportional to the deflection, we may take it that the first current equals 3 units, and the second 2; and from the formula $C = \frac{E}{R}$ we get, first, $3 = \frac{6}{R}$, and second, $2 = \frac{6}{R}$. Therefore the first resistance equals 2 units, and the second 3 units. Thus the second wire has a resistance of one and a half times the first one.



3. CONNECTIONS FOR INSULATION TESTING

Insulation Resistance Test. In the actual testing of cables the resistance which the insulation should offer when sound is first calculated, and the circuit is made up of a powerful battery, a galvanometer, and a known high resistance, which is approximately equal to what the calculation gives. Figure 3 shows a diagram of connections for insulation resistance testing. A deflection is obtained with the known resistance in circuit by pressing the key K into contact with R. The known resistance is disconnected, and one pole of the battery is connected through the galvanometer to one end of the cable by pressing the key to the right to make contact with C. The other end of the cable is left entirely free, not even allowed to touch the sides of the tank in which the body of the cable lies. The other pole of the battery is connected to earth at E. To complete the circuit, the electricity will have to flow from the battery through the galvanometer into the cable, through the insulation into the water, down the sides of the tank to earth, and along the earth to the wire earthed at E. Thus it will be noticed that the electricity will have to go *through* the insulation as it had to go *through* the known high resistance, and since these are, approximately, equal, the deflection obtained when the cable is in circuit should be nearly the same as that when the known resistance was in. This will be the case when the cable's insulation is sound, and when the ends, which are never allowed to touch the water, are painted with paraffin wax for the purpose of preventing surface leakage.

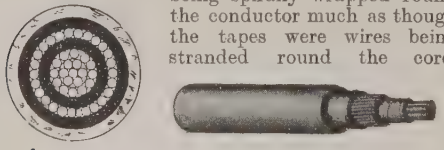
A point may be mentioned with regard to reading the galvanometer deflection when the cable is in circuit. When the electricity enters the instrument, a deflection will be shown, but as the electricity continues to flow the deflection will gradually decrease for a few minutes, and then remain stationary. This slow decrease is due to the electrification of the cable; that is, the absorption by the cable of a certain quantity of electricity into itself. The amount of absorption is known as the *capacity* of the cable. If the decrease is very slight, or proceeds unsteadily, there is probably a defect in the cable. This property of electrification may be used as a further test for the soundness of the cable in this way. If after electrification the cable is connected to earth through the galvanometer after the battery has been removed, the deflection of the galvanometer will show that a steadily decreasing current is flowing from the cable. If the deflection decreases at the same rate as when the battery was first put on, the cable is sound.

Testing Capacity. The capacity of the cable may be tested by comparing it with a condenser of known capacity. The condenser is first charged by a battery, and then the accumulated charge is sent through a galvanometer. The cable is first connected to earth to remove all residual charge, and then electricity is sent through it until it has absorbed to its full capacity. This point is reached when the galvanometer needle remains steady. The battery is removed, and the cable connected to earth through the galvanometer, and the deflection compared with that obtained from the condenser. The capacities are roughly in proportion to the deflections.

Concentric Cables. These consist [4] of a prime central conductor, an insulation covering, a second conductor outside the insulation, a second insulation on top of the second conductor, and a protective covering. The second conductor is in the form of a copper wire ring, which is concentric with the prime conductor. The insulation in this make of cable is usually of paper or jute. The reason for this is that the second conductor could not be well applied on a soft indiarubber insulation before vulcanisation, because it might cut through the plastic substance and cause a fault. Further, if the first insulation were vulcanised before the second conductor were added, the second insulation would have to be vulcanised, and while this was being done the first insulation would be vulcanised again. This would destroy all the good properties of the first covering, and cause it to crack when bent.

To appreciate the necessity for this precaution, it should be recognised that the vulcanisation of rubber is not a definite chemical reaction between the added sulphur and the rubber. The sulphur is invariably added in some excess, and the condition of the finished article determined not only by the amount of sulphur added, but by the degree of heat applied and the length of time the vulcanisation occupies. The degrees of vulcanisation are, for practical purposes, infinite. Starting at one end of the scale, we have rubber vulcanised on the surface only by the application of a liquid containing sulphur; then by gentle gradients the scale can be ascended until vulcanite itself is reached, which is no longer an elastic body, but a hard material containing up to 50 per cent. of sulphur, and which has been exposed to a higher temperature and for a longer length of time.

Making Concentric Cables. In the making of concentric cables, the first process is the making of the central stranded conductor by means of the stranding machine, as already mentioned. The conductor is taken from the stranding machine to the paper-lapping machine, where it receives a covering of several layers of strong manilla paper tape. This is applied by being spirally wrapped round the conductor much as though the tapes were wires being stranded round the core.



4. CONCENTRIC CABLE—LEAD COVERED

Each layer of paper is wrapped on in reverse spiral, for the reason stated, with rubber strips. The paper-covered core is now placed in a hot-air chamber, heated to about 250°, to drive out all moisture. Since the paper will again absorb moisture from the atmosphere if left about, it is at once taken to the tanks containing a special hot resinous compound. The paper is thoroughly impregnated with this compound until it is practically waterproof. At the same time, the compound adds a little to the better insulation of the cable. From the tanks the cable is again taken to the stranding machine, where it receives its second conductor. This requires careful application, since, when it is on, the wires forming it must have a combined sectional area equal to that of the prime conductor, because both will have to carry the same amount of current with the same amount of resistance. If the sectional area differed, the smaller conductor would offer more resistance than the greater to the passage of the same amount of electricity. This would cause waste of current and more heat in the circuit, therefore both conductors should be of the same sectional area. The second insulation is now applied by the wrapping, drying, and impregnating processes as before.

Lead Covering. With a moisture-absorbing material like paper a waterproof covering is necessary; therefore, as the cable comes out of the compound tanks for the second time it is taken to the hydraulic lead press to be encased with a lead sheathing. The method of applying this has been much discussed among cable-makers, some preferring to put on the lead at a high temperature with low pressure, and others at a lower temperature with high pressure.

In the former method, the lead is very liable to small air holes, or pores, and the thickness of the sheathing is not usually the same all the way round. In the second method, owing to the increased pressure, porosity is less likely to occur, and the thickness of the covering is more smoothly and evenly maintained; hence the high pressure process is now becoming general. At the hydraulic press the cable passes through the centre of a die, through which the lead is forced at the same time under very great pressure and at a temperature well below melting point. This gives the cable a closely-fitting protective sheathing against dampness and mechanical injury. With the lead covering on, the cable is ready for testing. In connection with these paper-insulated cables, the great difficulty is to prevent dampness getting to the insulation, because dampness not only conducts electricity, but also quickly rots the paper and causes a fault. When a fault occurs, there is no telling what may happen, so that it behoves makers to see that the cable is sound before it leaves the works.

Testing Lead-covered Cables. The testing of lead-covered cables is rather difficult to conduct in a satisfactory manner. The cable is first placed in water-tanks, and left there for about twenty-four hours, the ends being carefully kept out of the water, because they are not fully protected against dampness. When the test for insulation resistance is made, the ends are carefully prepared to prevent surface leakage by being coated over with an insulating compound. Both the waterproof and the insulation resistance tests are very similar to those for india-rubber insulated cables. It will be noticed that the concentric cable is not tested as soon as the insulation is applied, as the single cable was, and the reason for this will be readily understood when it is remembered that the chief idea right through the process of making the cable is to prevent dampness in the paper.

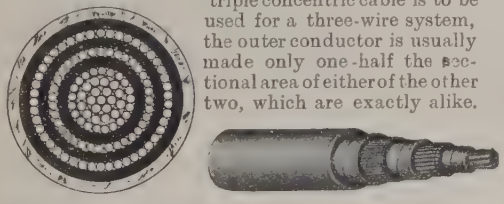
The unsatisfactory part of the testing when the lead covering is on is this: owing to the method of application, there is always the possibility of weak places occurring in the lead. These will withstand the tests when the cable is newly made and before it has been wound many times on a drum, but very soon after it comes to be wound and unwound in the process of laying, the weak places break down, and when next the electricity is sent through there is a fault shown. After the testing the cable is ready for use. Since lead soon decomposes when laid in the ground, this class of cable is usually laid in conduits. The concentric cable, having two conductors, may be used alone.

Twin Cable. This is called a twin cable [5] because it has two similar insulated conductors bound together under one protective covering. The two conductors are stranded separately at the machine, and each is separately insulated by indiarubber, bitumen, or paper.

5. TWIN CABLE—DOUBLE-STEEL TAPE ARMOURED

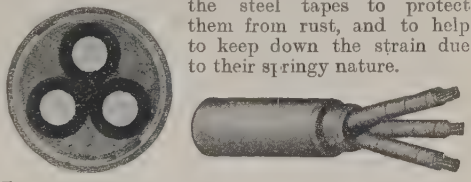
As the conductors are usually small in twin cables, they can generally receive their insulation, if of indiarubber, at the longitudinal machine. If bitumen or paper is used, the insulation is applied by the wrapping process. After receiving the insulation of indiarubber, the cables are tested in a manner similar to the single indiarubber cable. Up to the testing process the two conductors are treated as separate cables, but from this point they become as one. If they withstand the tests satisfactorily, they are placed side by side and closely packed round with broken jute, usually impregnated with resinous or tarry compounds. A stout jute braid is then applied round the packing to keep it tightly in its place, and to make a solid core around which a lead covering or wire armouring may be placed. Before the armouring is applied, the braided cable is passed through the serving tanks to receive its covering of compound, which acts as a preventive against dampness. The lead covering is also put on for this purpose, but it further acts as a mechanical protection.

Triple Concentric Cable. This [6] is so called on account of the three concentric conductors which are enclosed within its armouring. It consists of a central conductor, a first layer of insulation, a second conductor in the form of a ring, a second layer of insulation outside the ring, then a third conductor, again in the form of a ring of copper wire, and a third insulation. As the insulation is usually of paper, for the reasons stated for the concentric cable, the usual protective covering is the waterproof lead sheath applied by pressure. The stranding of the conductors, the wrapping of the insulation, and the pressing on of the lead are all done in the manner as described for the concentric cable. If the triple concentric cable is to be used for a three-wire system, the outer conductor is usually made only one-half the sectional area of either of the other two, which are exactly alike.



6. TRIPLE CONCENTRIC CABLE—LEAD COVERED

Three-core Cables. This cable [7], as the name implies, has three cores or conductors, each of which is separately stranded and insulated. All three are then bound together within one armouring. A sample of the three core cable before the writer is insulated with bitumen. To prepare this substance for insulation purposes, it must go through a thorough refining process. Much difficulty was at one time experienced in getting this material into such a condition that it was neither so brittle as to crack when bent nor so soft as to allow the heavy conductor to become decentralised when insulated with it. After the refining process the bitumen is compounded with chemicals, one of which is sulphur, and rolled into thin sheets. These are cut into narrow strips, which are wrapped spirally round the conductor, after a lapping of paper or indiarubber-covered cotton tape has been applied on the copper to prevent the sulphur in the bitumen from tarnishing it. The process of vulcanisation is the same as for indiarubber, and it is done for the purpose of adding strength and flexibility to the compound. Each conductor is generally of the same size, and insulated with the same thickness of material. When the insulation is vulcanised, the three cores are placed together and tightly packed round with jute soaked in oily or bituminous compound. A strong braid surrounds the packing, and on the outside of this the armouring is placed. This may take the form of galvanised iron wires, steel tapes, or lead sheathing. If steel tapes are used, they are applied by the steel taping machine and laid on in two spiral layers. The second layer is wound over the joints of the first, so that there is no joint showing right through the steel covering. Steel tapes are an excellent form of mechanical protection, as they are flexible and will withstand a lot of rough treatment without injuring anything underneath them. A covering of strong braid is usually placed over the steel tapes to protect them from rust, and to help to keep down the strain due to their springy nature.



7. SEVEN-STRAND THREE-CORE ARMOURED CABLE

Joining Cables. In the above descriptions only single lengths of cable have been dealt with. When a long cable is required, several of these lengths have to be joined together. The joining operation is very difficult, and much care must be taken in order to make a sound job. In the making of a joint the considerations to be borne in mind are that the joint should offer a resistance as near as possible to that of any other part of the conductor, the insulation about the joint should be as sound as any other portion of the cable, and the joint should be strong enough to withstand a certain amount of rough usage which it is sure to receive when being laid. The method of making the joint varies somewhat with the style of cable being joined. A common way of fastening together two lengths of small size cable (say, nineteen strand) is by what is known as the *married joint* [8]. To make this the conductors are stripped of their insulation for a short distance from the ends about to be joined. The bare conductors are then bound round with a few turns of thin copper binding wire at the place where the insulation ends. This is to keep the strands in place while the outer wires are bent back so as to disclose the central strands of seven wires. These are soldered up solid for some distance and then filed into a long bevel so that when placed together there will be a fairly large surface of each in contact with the other. The two ends are then held together while they are tightly bound with binding wire. The joint is then

soldered over and filed down smooth. The wires should be thoroughly cleaned before joining so that the solder will run well on them. The outer wires, which have been bent back, are now cut off at suitable lengths, alternate ones of each conductor being cut long and short. These are then butted together so that a long wire from one side butts against a short one of the other, and molten solder is poured over the joints, after binding wire has been wrapped over them. Figure 8 shows this joint.

The solder is filed down to smoothness so that there will be no sharp projections which might pierce the insulation. The reason for cutting off the outer wires in alternate long and short lengths is to avoid the overlapping of the wires and to make the finished joint as nearly as possible the same thickness as any other portion of the conductor. If the conductor is a very small one (say, of only seven wires), it is usually joined by one joint in a similar manner to the central strand as described above.

The Telescopic Joint. Another simple way of joining small cables is by the telescope joint as shown in 9. To make this the conductors are stripped of their insulation for a short distance and then bound with wire as before. The outer wires of one conductor are then cut off at the binding, and the inner strand of the other is cut off at its binding. The outside wires, B, now remaining are laid up in position again so that they form a hollow cylinder into which the projecting central strand, A, of the first conductor, after being soldered up solid, is inserted. The end of the hollow cylinder touches the binding at which the outer wires were cut off. The whole joint is tightly bound with wire, and then soldered over and filed down smooth, after which it is ready for insulating.

In the concentric cable the inner conductor is joined by the single or married joint, according to size, and then insulated, the outer wires, or the second conductor, having been turned back out of the way. A sleeve of clean copper is usually placed over the joint on the outside of the first insulation, and on the top of this sleeve the second conductor is married, bound, and soldered as mentioned before. In joining concentric cables great care must be used so that the first insulation shall not be damaged in any way during the process of joining the second conductor. The second insulation is applied and then the protective covering.

Joint Boxes. Large cables are usually joined in specially made joint boxes filled up solid with compound to make them watertight and to improve the insulation.

When joint boxes are not used the insulation of the joints in cables is a very difficult matter, as will be readily understood when it is stated that these are the places in which the conductor will offer most resistance and consequently generate most heat. Further, the insulation will have to be tightly and soundly applied without any of its properties being impaired in any way. There are two ways of reinsulating the joints in indiarubber-covered cables; one by means of pure indiarubber, and the other by vulcanising indiarubber. The pure indiarubber joint is made by stripping back the tapes and braids so that they will be clear of the part to be reinsulated. When the indiarubber is thick enough the surface which has been exposed during the making of the copper joint should be trimmed down to the conductor in a long bevel.

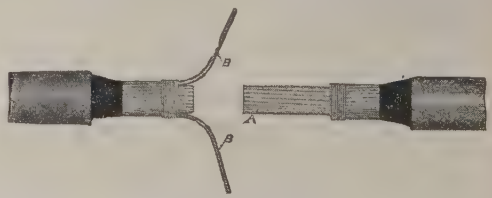
This will expose a new, clean surface, to which the pure indiarubber strip about to be applied will stick better. If the copper joint is clean and smooth, the pure indiarubber strip is wrapped tightly and evenly round it, and over the bevelled surfaces, until a thickness equal to, or slightly greater than, that of the old covering is obtained. Strong tapes are then soaked in compound and tightly wrapped over the strip, and for a short distance over the original braiding. The whole joint is then

8. MARRIED JOINT

painted over with resinous, water-resisting compound. When the indiarubber insulation is not thick enough to be bevelled down, the new rubber may be lapped for about an inch or so over the old, which ought first to be well scraped and cleaned to remove all grease and dirt. This kind of reinsulation of joints answers all practical purposes in indoor low-pressure circuits where little moisture penetrates and little heat is generated.

Joining Cables Out of Doors. The making of a vulcanised indiarubber joint out of doors requires special apparatus, since it is practically impossible to carry about with one a steam generating plant and vulcanising pans. The molten sulphur bath is probably the most satisfactory portable vulcaniser for outside work. The bath may consist of a strong, cylindrical box, made in halves, and flanged so that they may be bolted together to enclose the joint. The upper half contains a hole through which the molten sulphur is poured, and through which a thermometer is placed so that the temperature of the sulphur can be read. The bottom half contains a tap, through which the sulphur is run out after the process is over. When the box is screwed up with the joint inside, the openings through which the cable passes are packed with common rubber to protect the insulation from the heated flanges.

The preparation of the joint for the insulation is similar to that described above. When the bevelled edges have been cleaned, a lapping of pure indiarubber strip is tightly applied so that it just overlaps the thin edge of the bevel. On the top of this the strips of vulcanising indiarubber are firmly

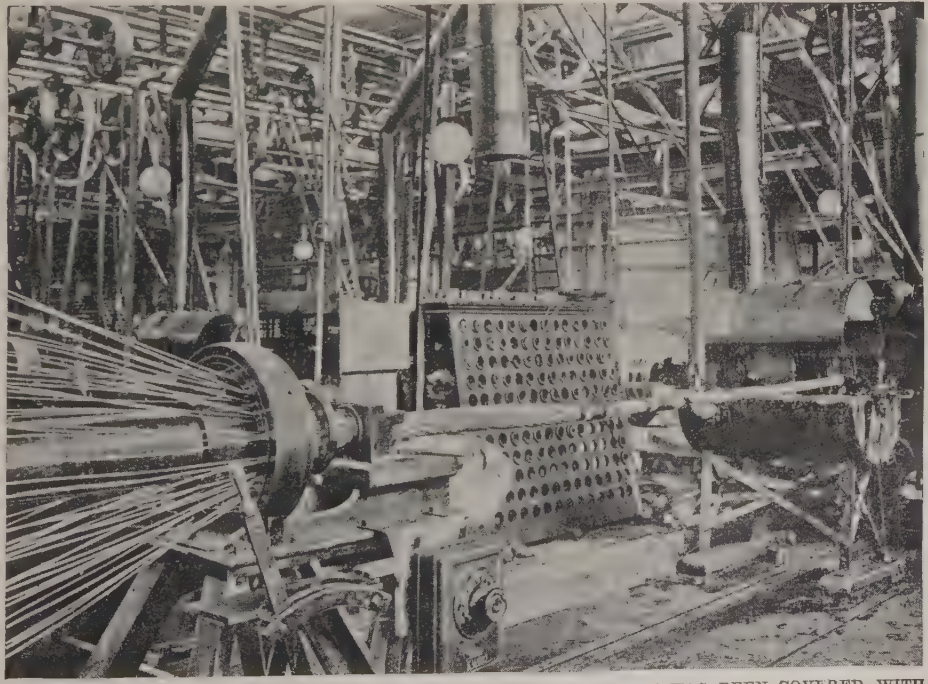


9. TELESCOPE JOINT

wrapped until the insulation about the joint is the same diameter as any other portion of the cable. The tightness and evenness of wrapping are essential to prevent small air spaces being left between the layers of insulation. A spiral wrapping of indiarubber-covered tape is placed over the vulcanising

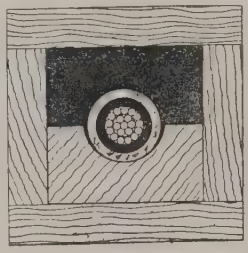
THE CABLE THAT LIES ON THE OCEAN BED

THE SHIP THAT LAYS THE SUBMARINE CABLE, SHOWING THE ELABORATE STRUCTURE FITTED TO THE STEM TO FACILITATE THE OPERATION OF PAYING OUT



MACHINERY BINDING WITH WIRE A SUBMARINE CABLE AFTER IT HAS BEEN COVERED WITH THE GUTTA-PERCHA WHICH ACTS AS AN INSULATOR

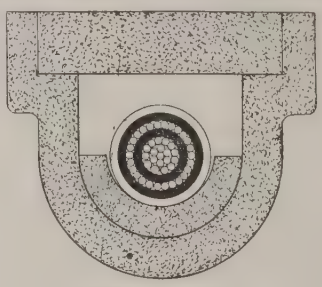
rubber, and in order to keep the insulation in shape, and under pressure, a piece of sheeting is tightly rolled over the tape so as to form a longitudinal seam. On this a spiral wrapping of strong unprepared tape is applied. The sheeting and unprepared tape merely act as a mould while the joint is being vulcanised. As soon as the process is over both are removed. The sulphur is melted over the fire used for heating the soldering irons, and is poured through the top hole in the box. The temperature is maintained by placing spirit lamps under the box. It is advisable to heat the box first so that the temperature of the sulphur will not be greatly diminished when it comes into contact with the metal. After the sulphur has been kept at the proper temperature for the requisite time, it is run out, the box is unbolted, and the joint allowed to cool. The operation is over. A rough test for the degree of vulcanisation may be made by pressing the indiarubber, when cool, with the thumbnail. If this leaves no mark, the rubber may be considered to be correctly cured. If a mark is left the indiarubber is probably under-vulcanised, and if the substance feels hard and solid so that the nail makes no impression, over-vulcanisation has probably occurred. The vulcanised joint is protected by strong tapes and braid, which overlap for a short distance the original braid on the cable. Joints in bitumen-insulated cables are made in a similar manner to those described above, but the paper cables are more commonly joined in special joint boxes, which are watertight and take the place of lead covering.



10. SOLID SYSTEM OF CABLE LAYING

Testing Joints. When the joints are completed, they should be tested to see that their insulation resistance is not much different from that of an equal length of continuous cable. There are several ways of testing joints, but a simple and effective one is known as the accumulation method. The joint to be tested is placed in water contained in a trough which is thoroughly insulated by being raised from the ground on blocks of insulating material.

The trough should be tested before proceeding with any other tests. The length of cable containing the joint is connected to one pole of a battery, the other pole of which is connected, through a condenser, to the water by a wire, which is not allowed to touch the cable. The current passing through the insulation of the joint escapes through the water and along the wire to the condenser. This is then disconnected from the trough and connected to a galvanometer, through which the condensed or accumulated current passes, and gives a deflection. The joined length of cable is removed and a continuous piece substituted; the condenser is again connected with the trough and again collects the current passing through the resistance of the cable under test. The battery is kept on for the same time in both cases. The second accumulated current is sent through the galvanometer as before, and if the deflection obtained in the second case varies but slightly from that of the first, the joint may be considered satisfactory.



11. CONCENTRIC CABLE LAID IN STONEWARE CONDUIT

The trough may be tested by passing a current through an electrometer until a steady deflection is obtained. The battery is removed and the electrometer connected to the trough. A decrease in the deflection of the instrument takes place, but if this decrease is only very slight, the trough is sufficiently well insulated for testing purposes.

Cable Laying. When the joints are tested and found sound the finished cable is ready for laying. The question of whether the cable should be laid underground or overhead is soon decided. In England the only method allowed in any of the large towns is the underground system, although under certain circumstances, especially for the transmission of electricity over long distances, the overhead lines may have decided advantages. Overhead wires are chiefly confined to outlying mining districts. There are many in South Wales. The several ways of laying cables underground may be grouped into two classes: (1) the "built-in," or "solid" system and (2) the "drawn-in" system. Figure **10** shows a lead-covered cable laid on the solid system, and **11** shows a cable laid in a conduit in the "drawn-in" system.

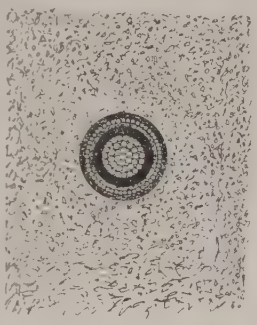
Access to built-in cables, when once they are laid, can be made only by opening up the ground, whereas in the drawn-in system, the cables, lying as they do in conduits, may be easily withdrawn into the nearest surface box for inspection. Greater mechanical protection is required in the "solid" method than in the "drawn-in." This is because the cables in the solid system are sometimes laid in the ground direct [12]. The armouring may consist of steel tapes, or iron wires, or the cables may be laid in troughs of wood or iron, filled up solid with compound. Sometimes broad tiles are placed just above the cables to give warning to workmen when opening the ground that the cable is at hand. Precautions are then taken that the pick or spade is not sent through the cable's insulation. In these troughs a good plan is to lay the cables on small bridges of wood, as shown in **10**, before filling up with the compound or asphalt.

Whichever of these plans is adopted, the cables must be laid while the ground is open, and this is a great inconvenience to traffic if the laying happens to be in a very busy thoroughfare. Further, the road authorities allow only a certain length of trench to be open at one time, and this is often a hindrance to rapid laying. When a length of trench is prepared, the drum containing the cable is mounted on a trolley and wheeled along the side of the trench so that it pays off the cable, which is laid in place in the trough. Hot compound is then poured over it. The trench is filled up, and the surface repaved.

Drawn-in System of Laying. In the "drawn-in" system it is not necessary to go to the expense of strongly armouring the cables because they are provided with mechanical protection by the conduits into which they are drawn. The pipes or conduits are placed in the ground before the cables are drawn into them, and when once they are in position the ground need not again be opened. For the purpose of drawing the hauling line through the conduits, a wire is threaded through each section

of them, as they are laid, and it is fastened in the surface boxes. When the conduits are laid, the drum containing the cable is conveniently placed on an axle near the mouth of a surface box, and the end of the cable is connected, by a smooth, strong, fastening, to the hauling line, which is then drawn through the conduits by the wire left for that purpose. The rope is then used for drawing in the cable. The length of cable which may be drawn in at one hauling depends partly upon the weight of the cable but chiefly upon the straightness of the conduits about to be entered. In town work the lengths are usually short on account of the numerous sharp bends encountered. When a bend is reached, a length of cable, sufficient to reach to the next surface box, is drawn through and laid on the ground in long loops. The hauling rope is drawn on as before, and then the loops of cable gradually disappear into the conduits. The reason for raising the length of cable to the surface at the bend is to avoid the friction and extreme tension which would arise from the cable being drawn round a sharp corner. Even in straight lengths of conduit the friction is very great, and to reduce this as far as possible a coating of whiting is often applied, as a lubricant, to the cable. Sometimes a chain is drawn through the pipes to clear away any obstacles which might increase the friction or tension on the cable that follows. If the conduits are smooth to begin with, and these precautions are taken against friction, the possibility of damage to the cable during the drawing-in is reduced to a minimum.

Conduits. The cost of conduits is a considerable item. When large-sized cables are laid, a separate way is usually provided for each one, although smaller sizes may be drawn in in pairs. This question of cost has led many people to turn their attention to the manufacture of cheaper kinds of pipes which can be readily joined together. Brick culverts are rarely used now because they take up much space underground, they occupy a long time in building, and are very costly. Earthenware conduits, with two or three cable-ways, can be laid much more quickly and cheaply, and they are now manufactured in a special way so that the joints can be easily made. The disadvantage of earthenware pipes is that they are very liable to fracture, and on account of this other kinds are sometimes substituted.



12. WIRE-ARMOURED CABLE LAID DIRECT IN THE GROUND

Bituminous concrete conduits are often used because they are fairly cheap. They are made in blocks with two or more passages, and are joined together by inserting short mandrels in each passage of two blocks while hot bituminous compound is poured into the joint and allowed to cool. When the mandrels are withdrawn the compound has formed a joint between the two blocks, and the mandrils have kept clear the passages through which the cables will be drawn. Cast-iron pipes are extensively used in connection with Post Office cables, as they have been found to be the most satisfactory.

Considerations in Laying. In deciding at any place whether the cables shall be laid by the "solid" or "drawn-in" systems, considerations are given chiefly to the cost of the cables and conduits. If the "built-in" cables are laid in iron troughs filled up solid with compound and the "drawn-in" system has cast-iron pipes for conduits, then the cheaper method is probably the latter, as in this the cables are not usually so strongly armoured as in the former. After the cost the convenience of access in the "drawn-in" system strongly recommends this method, although it has several disadvantages. The conduits are always liable to infiltrations of water and gases, and if the insulation is not perfectly waterproof, a fault may easily occur. Further, wherever gas collects there is always the possibility of an explosion. The conduits are usually connected with the drain pipes so that the water may run out almost as quickly as it enters. In the solid system there are no spaces in which gas may collect, and the insulation is usually waterproof, therefore the small amount of water which may penetrate the compound around it may be ignored.

Uses of Different Insulations. The different kinds of insulations mentioned have their respective advantages and disadvantages for special classes of work. For a material to be a good insulator it should be moisture-resisting, because moisture is a conductor, and lowers the effectiveness of the insulation; it must be strong and tough, so that it can withstand the rough usage it receives in laying without splitting or tearing, and it should be flexible so that it can be easily wound on drums or bent round sharp corners underground. Further, it is desirable that it should withstand a fairly high temperature without being injured permanently, as heat is generated by the passage of the current along the conductor, and it should be practically unaffected by the acids and gases it is likely to meet when laid in the earth. In high-pressure circuits the insulation must be a very homogeneous mass, because it has to offer great resistance to disruptive discharge. When an installation is found with all or most of these properties, the best cable is that in which the cost, bulk, and weight are least. Good quality of indiarubber, properly applied, possesses almost all these qualities; therefore, from a purely technical point of view it is undoubtedly the best insulator known. Its one great disadvantage is that it is expensive.

Bitumen compound is a fairly good insulator for low-pressure work, but as it cannot withstand much heat without softening, it is unsuitable for heavy current work, where a large amount of heat is generated. Its resistance, thickness for thickness, is not quite so good as indiarubber, but it has the advantage of being cheap. Gutta-percha has a comparatively low melting point, and is therefore confined chiefly to insulation of submarine cables, and underground telephone and telegraph wires, which work only at low pressure. The advantages of gutta-percha for these insulations are that it is thoroughly waterproof and lasting. Paper insulations are suitable for either high or low pressure circuits as they will withstand a fair amount of heat without serious injury. Their disadvantages are that the paper readily absorbs moisture and therefore always requires a lead or other variety of waterproof covering, which adds to the expense. The paper itself is inexpensive.

Voice Production and the Vocal Organs. Classification and Characteristics of Different Voices. Breathing Exercises.

HOW TO SING

It would not be true to say that a voice can be created or made by a teacher of singing; but all voices, good, bad and indifferent, may certainly be greatly improved and developed by a proper method of voice production.

The First Essentials. It is not enough to sing the melody perfectly and pronounce the words clearly; more than these qualifications are needed. A perfect understanding of the subtleties of a song is required if the listener is to be moved. The student should try to realise, as he sings, how he would feel were the words of the song his own and the outcome of his own feelings.

It is possible for everybody to do this, although in some natures the gift is more developed than in others.

The artistic side of the art of singing, however, should never tempt any singer to neglect or depreciate the technical side of it. It is essential that the æsthetic part of singing should be preceded by a thorough technical study.

First and chief of such studies is a correct method of breathing. Too great importance cannot be attached to this. Some of the old Italian singing masters used to say that "breathing well meant singing well." Perhaps this is rather an exaggerative assertion, but, at any rate, it is certain that a person cannot sing properly if he cannot breathe properly. It requires diligent and careful practice, but if the student will be advised by a thorough and experienced teacher, he will surely make up his mind at the very beginning thoroughly to master the art of respiration.

Training the Vocal Organs. Having at last so far succeeded in this all-important study, he may then turn his attention to the training of the vocal organs. It must be borne in mind that voice production cannot be forced; it must be developed slowly and surely, or the result will be disastrous.

The study of songs must not be entered upon at too early a date; let the student work at scales, exercises and solfeggi until he is able to sing them without being in the least conscious that he possesses a throat, or, in other words, until his production is perfectly easy. He will then be able to give the whole of his attention to the meaning of the words and the conception of the song, because, through careful, conscientious, and regular practice the technical side of his art will have become "second nature" to him.

It is not the singing voice alone that is benefited; the speaking voice, too, receives a large share of the profits.

Four distinct attributes are essential to musical sound—*Volume, Pitch, Quality,* and *Duration.*

Volume (strong or weak) depends upon the vocal cords, the resonance chambers, and the relative amount of breath pressure.

Pitch (the height or depth of a note) depends upon the number of vibrations in a given time.

Quality depends upon the pharynx principally, together with the cavities of the chest, mouth and head, which act as resonators.

Duration depends entirely upon the breath.

The production of very few voices, either in singing or in speaking, is quite perfect. The voice should be trained in order to make it respond to the will, to make it firm, reliable, strong, and flexible, easy to use, and to ensure correct intonation (to help a person to sing in tune); to point out and correct faults; to understand the art of phrasing; to bring out the various degrees of expression, and to become familiar with the different styles of singing.

How the Voice is Produced. The human voice cannot be described as any particular instrument or thing. To produce it there must be four distinct organs, working together, but quite independent of each other. They are:

The Bellows, properly termed the lungs, together with the wind or breath.

The Voice-box, properly called the larynx.

The Resonator, properly called the pharynx, together with the mouth and nasal cavities.

The Articulator, which consists of the tongue, teeth, lips and mouth.

Given these four requisites, voice can be produced by filling the lungs with air and allowing it to pass out through the mouth. A man, mentally, though probably unconsciously, says he wishes to utter a sound, or to sing; the breath is the motive power, and as it passes from the lungs it travels through numerous tubes until it reaches the larynx or Adam's Apple. In the Adam's Apple, or voice-box, are two ligaments which lie across the throat from front to back. When the order is given for a sound to be produced, these ligaments unconsciously close, and the breath strikes against the edges of them, setting them vibrating or oscillating, and the issue is voice, or sound. The ligaments are generally called the vocal cords or vocal lips.

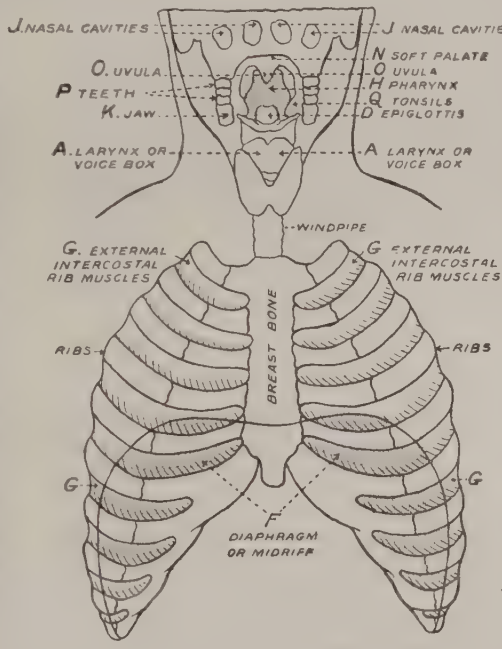
It requires careful study and much thought fully to understand the parts used in tone-formation.

Naturally it is much more difficult to grasp the principles of singing than of instrumental playing, because the student can *see* the different movements and actions necessary, whereas with the singer much has to be taken for granted.

He has to trust chiefly to his hearing—which at best is only an after-effect—for he cannot, except mentally, direct his vocal cords, and certainly cannot see them working. There must, of course, be no trusting to chance. It is very important that he must know exactly what tone and effect he is striving for, and, to acquire these desired effects, it is necessary to know something of the anatomy of the vocal instrument. In order that the student shall not become wearied, the descriptions of the various organs used in voice production are set down as concisely as possible [1 and 2].

The Larynx. The apparatus by which vocal sounds are produced is called the larynx, which is the special organ of phonation. It is placed at the top of the windpipe, immediately under the floor of the mouth. If the fingers are lightly placed on the projecting part in the forepart of the neck, it will be found that, when swallowing, that part moves up and down, and that is the larynx or voice-box, more commonly called Adam's Apple. It is triangular in shape, and open at both ends, top and bottom, so that the breath can pass in and out from the lungs. It is more noticeable in men than in women, and it is easy to see it move up and down as they talk. [1A]

Vocal Cords. Inside the triangular-shaped box, or larynx, are two flat horizontal folds, or cords, which stretch across the throat from the front to the back. These are the vocal cords. It is the greater or less tension of these, together with the breath, that gives us what we know as sound or voice. The higher the pitch of the note, the greater is the tension and more closely together are the vocal cords. [2B]



1. THE PRODUCTION OF THE VOICE

The Glottis. The space between the vocal cords is called the chink of the glottis. [2C]

The Epiglottis. At the top of the larynx is a self-acting cover, or lid, which is not unlike a bird's tongue to look at. Directly a person wishes to swallow, this little lid, called the epiglottis, shuts down tightly, like a miniature trapdoor, on to the windpipe (trachea), the object being to prevent food from passing into the larynx. Who has not felt the unpleasant sensation of choking when food has gone the "wrong way"? This happens when the epiglottis does not do its work quickly enough. [1D]

The Lungs. The lungs, which are two in number, called the right and left, are the bellows of the human body. They are a very spongy and elastic tissue, and may be likened to two sponges. They are capable of great expansion and contraction, and are placed, or, to be more correct, suspended in the upper part of the body, which is called the chest (thorax). They are connected to the windpipe by two tubes, which divide and subdivide until the size of the smallest pipe, if such it can be called, is about the fortieth part of an inch long. At the end of each tube, or pipe, is a minute air-cell. In the chest, which is an air-tight compartment, the lungs and the heart fit quite closely. The floor of the chest is known as the diaphragm, of which more will be said later. The walls or sides are formed by the ribs, together with the breast-bone. [2E]

The ceiling, or top, is formed by the ribs, collar-bone, and the root of the neck. The lungs rest, as it were, on the diaphragm. The size of the lungs depends entirely upon the size and build of the body. Their colour is a kind of purple, or rather dark bluish red. Their chief work is to supply the blood with pure air and to free it from carbonic acid; it is quite necessary therefore always to breathe fresh air.

The Diaphragm or Midriff. The largest muscle in the body is an involuntary one, called the diaphragm, or midriff. It divides the upper part (the chest) from the lower (the stomach); that is, it lies across the body. The outer parts are fixed to the lower ribs.

When the lungs are almost empty, or, in other words, during the act of exhalation, the diaphragm is almost dome-like in shape. As the lungs fill with air they press on the diaphragm until it becomes much flatter in appearance. Only will power can control this huge muscle, and, as it plays such a very important part in the art of respiration, the student cannot be too diligent in his endeavour mentally to control it. [1F].

The Rib Muscles. On each side of the chest there are twelve ribs, making twenty-four in all. Each is connected with the backbone or vertebral column; they curve round to the front, and seven pairs, counting downwards from the neck, are joined to the breast-bone;

the eighth, ninth and tenth are joined to the seventh, whilst the eleventh and twelfth pairs are not attached to any part in the front, and are commonly called the "floating" ribs. Connected with the ribs are two kinds of muscles—the outer and the inner *intercostals*. As the lungs become inflated the outer intercostals raise the ribs upwards and outwards. As the lungs empty themselves, the inner intercostals come into play and bring the ribs back to their former position. The student's attention is drawn particularly to the movements of these muscles, as a thorough understanding of their working is essential before he can master the art of breathing. [1G]

The Pharynx. The pharynx, or throat chamber, is the cavity situated in the upper part of the throat, behind the mouth. There are five openings into it—from the ear, nose, lungs, mouth and stomach.

The throat chamber is subject to great variations, being capable of great expansion and contraction. It is the principal resonance chamber of the voice. The colour and timbre, as a matter of fact, depend almost entirely upon it. [1H]

The Nasal Cavities. The nasal cavities are really the external and internal nostrils; the last named join the pharynx. The hard and soft palates make a floor for them. The nasal cavities assist very considerably in tone production, by helping to make the voice more resonant. [2J]

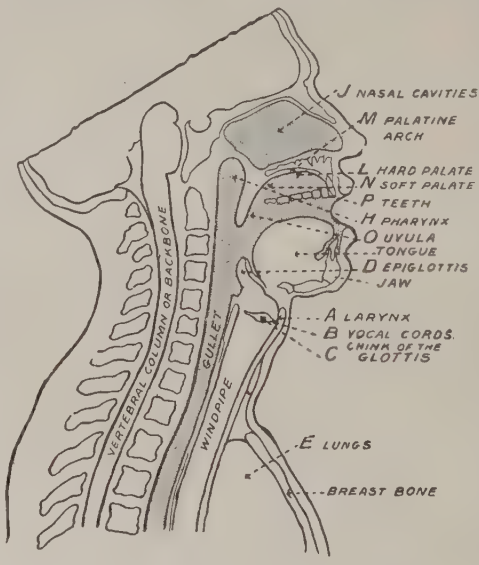
The Jaw. The lower jaw plays a very prominent part in the art of singing, helping principally in pronunciation. It is essential that it should be kept loose and free. Lamperti, in his famous "Treatise on Singing," attaches great importance to this. When the jaw is loose and free, so are the muscles of the throat. The distance between the teeth should never be less than a thumb's width when singing. [2K]

Hard Palate. If the student places his finger inside his mouth immediately behind the upper teeth, he will find a hard, fixed and slightly ribbed substance; it is known as the hard palate. On moving his finger a little further along the hard palate, he will come to a dome-like part; this is called the Palatine Arch [2M]; these two greatly influence vocal tone. [2L]

Soft Palate. Carrying the finger still further into the mouth, the student will come to a very sensitive, soft, fleshy and movable part of the roof, which possibly he may not be able to touch without feeling sick. This is called the soft palate. It consists of a number of muscles which work at will. If the student draws in a breath through the mouth as if he were going to yawn, he will feel his soft palate rise, and it will appear to become a continuation of the hard palate. He should practise raising his soft palate in this way, so that when he sings he will be able to raise or lower his palate at will. One of the most common faults of singers of the present day is their inability to do this, and in consequence they almost invariably sing with their palates "down." This makes the tone nasal and indistinct, and prevents the voice from "carrying."

These two palates may be called the sounding board of the voice, and the correct use of them is of the greatest importance. [2N]

The Uvula. At the back of the mouth, suspended from the middle of the soft palate may be seen a soft red piece of flesh about the size of the kernel of a hazel nut. This is the Uvula. It rises with the soft palate, and in some mouths seems to disappear altogether. Its work is to close the nasal passages, and so prevent the tone from becoming nasal. This does not, however, interfere at all with nasal resonance. [2O]



2. THE PHYSIOLOGY OF THE VOICE

The Teeth. No opportunity should be lost for impressing upon the student the great necessity for taking care of his teeth. Their work in singing is to help in the articulation of the consonants. A song becomes stupid and feeble when the consonants cannot be heard clearly and distinctly. The consonants, not the vowels, are the backbone of diction, and since the consonants are formed largely by the teeth, the care of the teeth is one of the first considerations in singing. [2P].

Classification of Voices. Generally speaking, human voices may be divided into two large classes, male and female. These are subdivided as follows:

MALE.

BASS. BARITONE. TENOR. ALTO, OR COUNTER-TENOR.

Basso Profondo. Basso Cantante. Tenor Robusto. Tenor Leggiero.

FEMALE.

CONTRALTO. MEZZO-SOPRANO. SOPRANO.

Soprano Drammatico. Soprano Leggiero.

The quality of the middle notes of a voice, not the compass, determines its classification.

The student cannot be too particular in grasping this fact.

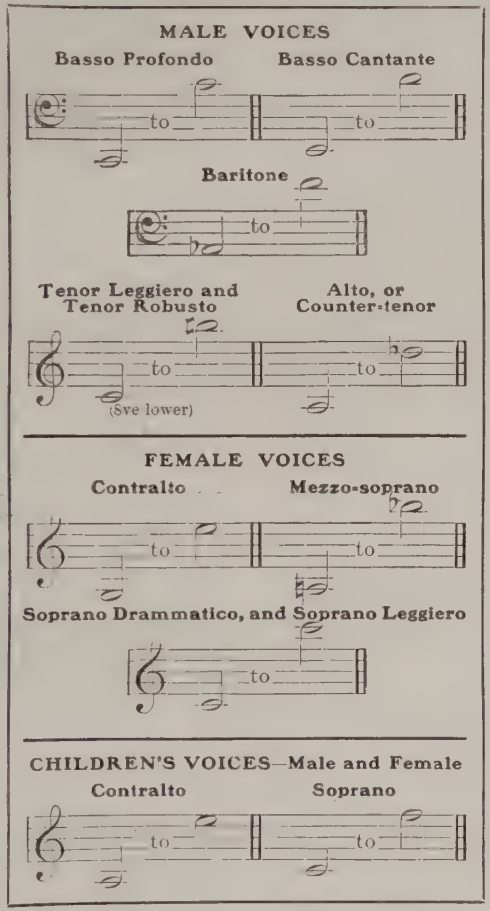
During the first singing lesson it is often difficult for a teacher to classify a voice definitely. A number of lessons may be necessary before such decision can be made. For example, a student may come to him and sing a song of soprano compass with effect; but because she is able to sing the head notes in a soprano voice—even if the compass is high—it does not necessarily follow that she is a soprano. The tone and quality of her middle notes must be listened to carefully by the teacher ere he can decide.

The vocal cords of a bass and baritone are broader, thicker, and longer than those of a tenor and soprano. The *kind* of voice—soprano or contralto—is governed, therefore, chiefly by the size of the cords.

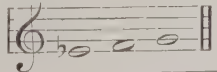
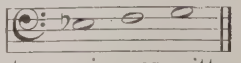
Although great similarity may exist, no two voices are quite alike; they differ in individuality as much as do faces, largely owing to the formation of the resonance chambers.

Compass. The compass of a voice is the range of sounds it is capable of producing, and these sounds are divided into registers. Each voice has three registers, which will be explained later. The table on this page shows the compass of the respective voices, but does not include voices of exceptional range.

Voice Characteristics. We must now consider the characteristics of the different voices.

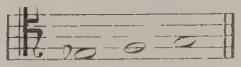
Basso Profondo. The Basso Profondo, which is the lowest male voice, is seldom met with nowadays. It is the fullest and deepest of all voices. Its chief characteristics are volume, intensity, richness, and broad phrasing; and its development is slow. There is always a great tendency to force, so the student must exercise much care and patience to avoid this fault, or the voice will become coarse. Another point to be carefully noted is the intonation. The vocal cords of a basso profondo are very thick, and in consequence the voice is particularly adapted to the sustained and declamatory styles of singing, but are, of course, quite unsuited for florid singing.

Basso Cantante. Although not so heavy, the Basso Cantante is more general than the basso profondo. Besides being lighter in quality, it has greater flexibility and a little higher range, as will be seen on reference to the compass. But, compared with the tenor and women's voices, it is deep and powerful. Its notes are capable of greater resonance than those of the baritone. The lowest notes, E, F, and F♯ in an untrained basso cantante voice may be weak, but with careful training they become full and rich.

Baritone. The Baritone in the classification of men's voices corresponds to the mezzo-soprano in women's voices, and partakes of some of the characteristics of both bass and tenor, with a greater resemblance to the former. It is capable of greater expression and modulation than the bass, besides being more flexible and mellow. It is the most general of all male voices. Although it does not possess the volume of the bass, it is fuller than the tenor. The great evil to be guarded against in the training of this voice is the tendency to shout and strain. The voice naturally is not the size of the bass, so the student must exercise great care not to force it or he will spoil the quality, and in time ruin the voice. The weakest notes of the baritone voice are the low A', A, and B.

Tenor. Of the male voices the Tenor is the highest. There are two kinds of tenor voices, the *Tenor Leggiero* or light tenor, and the *Tenor Robusto*, or full dramatic tenor. The volume and quality of these two varieties of tenor voices distinguish them from each other. The music for the tenor voice is usually written in the treble clef; it must be borne in mind, however, that the pitch of the notes actually sung by the tenor voice is an octave lower than that indicated. For example, the notes  when sung by a tenor are actually 

Originally, music for the tenor voice was written

in the tenor clef. The old clefs in singing are seldom used at the present. The above notes in the tenor clef would be written



Tenor Leggiero. The Tenor Leggiero, or light tenor, is noted for its brilliancy, lightness, and flexibility. The tone is most delightfully silvery, but wanting in sustaining power. It is, perhaps, the most difficult and delicate of all voices to train. It requires coaxing, then sweetness of tone and grace will result.

Tenor Robusto. The Tenor Robusto, or full dramatic tenor, like the basso profundo, is somewhat rare. It is full and rich, capable of great modulation, and can portray any passion necessary. The notes from F, first space, to B third line, are the most difficult to cultivate, and not infrequently are rather weak. Great care is necessary at the beginning of the training that the voice is not mistaken for a baritone. This is of the utmost importance, for if trained as a baritone, it will follow that the medium notes of the tenor are trained as baritone head notes, with disastrous results.

Alto. As a solo voice the Alto, or counter-tenor, is not very pleasing, but is useful as the highest voice in male part-songs and glees. It is most frequently met with in church choirs. Being an unnatural voice, very careful training is required.

Contralto. The Contralto is the fullest, deepest, and strongest of female voices, and is more capable of modulation and tender feeling than either the mezzo-soprano or soprano. Like the bass, it is not very flexible, and is particularly adapted to sustained and declamatory styles of singing. The weakest notes are from F, first space, to C, third space. Strict attention should be given to the cultivation of these notes during the first lessons, and special care must also be exercised to avoid forcing the chest notes, those from E, first line, down the scale.

With the majority of contraltos it is noticeable how weak are their medium, or middle, notes. This is due entirely to forcing the chest notes, which, when forced to any extent, become coarse and blatant, and produce, together with the weakened middle notes, the effect of two distinct voices.

The registers of contralto voices require the closest attention. Equality of tone is perhaps the most important feature to be developed in cultivating the contralto voice.

Mezzo-soprano. The Mezzo-soprano voice holds a similar position in female voices to that held by the baritone in male voices. It possesses some of the qualities of the contralto, notably fulness, mellowness, and roundness, being like the soprano inasmuch as it is capable of great flexibility. When perfect, it is often considered the most beautiful female voice; but it must be remembered that as it partakes of both contralto and soprano it must needs share the faults of both. Therefore, judgment and caution must be used in training to avoid its being taken too high or too low.

The greatest danger is that songs and exercises of too high a range are often sung by the mezzo-soprano, and if this practice is continued, the voice will be ruined. It is unadvisable, and often harmful, for a mezzo-soprano to sing contralto songs and exercises, although the result may not prove quite so disastrous as the singing of soprano songs.

At the beginning of study, let the middle notes be carefully trained, and the upper and lower notes develop naturally.

Generally, the weakest of all mezzo-soprano notes is E, fourth space

Soprano. The two kinds of soprano voices—the *Soprano Drammatico*, or dramatic soprano, and *Soprano Leggiero*, or light soprano—correspond almost exactly with the two kinds of tenor voices which have already been described. The soprano is the highest human voice. Because a woman's voice may be high in pitch, it is not necessarily a soprano—it may be a mezzo. The *quality* of the notes in every case decides the voice.

In training the soprano voice the tendency to overwork the highest notes must be strictly guarded against; if this injurious practice is continued, the tone will become weak, shrill, wiry, and thin.

The emphatic remarks made about the intelligent cultivation of the other voices previously noted apply with equal force to the light and dramatic soprano.

Respiration. It is of the utmost importance that before attempting to sing a note the student should try to acquire a correct method of respiration, or breath control.

The respiratory apparatus consists of the chest, thorax, and the respiratory tree (*arbre respiratoire*), which includes the larynx, the windpipe, the bronchi, and the lungs. The respiration of the animal kingdom is entirely opposite to that of the vegetable. In the former, oxygen is inhaled and carbonic acid exhaled; plants inhale or absorb carbonic acid and exhale oxygen.

Every human being and every animal from the moment of birth to that of death breathes; but very few of the former have naturally a correct method of respiration. It is essential that everyone, whether singers or not, should breathe in the manner intended by Nature. Unfortunately, civilisation, combined with the present mode of dress, has done much to hinder this. Savage races and the lower animals, whose bodily freedom is not impeded by clothing, breathe perfectly, because naturally.

The art of respiration comprises two movements—Inhalation or Inspiration, and Exhalation or expiration. With the former, life begins; with the latter, it ends. The average person inhales about 12 quarts of air per minute, 720 quarts per hour, 4,320 gallons per day The lungs, however, are capable of receiving seven times this amount.

Speaking of people in general, the quantity of air they draw in at each inspiration expands the

upper part of the lungs only; when the inspiration is *full*, the lungs expand at the base also.

The student's attention should be directed to the *muscles* controlling respiration, not to the lungs, which are passive. They of themselves cannot move or extend; it is the influx of air, together with the action of the muscles, that enlarge the lung space.

Exercises on the art of inspiration will follow. After the student has thoroughly mastered the art of inhalation, he may turn his attention to that of exhalation or expiration—the outflowing of the breath; but this must not be attempted too soon. Correct exhalation is even more difficult than correct inspiration.

Beauty of tone, phrasing, expression, duration, and so on depend entirely upon a correct mode of respiration.

Breath Management. Three methods of breath management are recognised: (1) diaphragmatic, (2) intercostal, and (3) clavicular; but the first, diaphragmatic, is the only correct method.

When diaphragmatic breathing is employed the lungs, which are fully inflated, press on the diaphragm [1F], and push it down on to the stomach, which in turn expands; at the same time, the outer intercostal muscles [1G] draw the ribs upwards and outwards, and in this way the cavity of the chest is considerably enlarged. The movements of these muscles are concomitant.

If the clothing is moderately loose, the diaphragm will work naturally, enabling the student to direct his whole attention to the movements of the rib muscles.

The shoulders should on no pretext whatever be raised during the act of respiration. Both the chest and stomach must expand whilst inhaling.

The second method necessitates the movement of the ribs only, which are raised and pushed out and the stomach slightly yet unconsciously drawn in, the diaphragm remaining stationary. Although frequently employed, this method is really insufficient, and often proves injurious.

The clavicular is decidedly incorrect; any student who understands the shape of the lungs and chest will perceive how pernicious it is, and abandon it at once. When this mode of breathing is practised, the diaphragm and the lower intercostal muscles are inactive, and their work is wrongly thrown upon the shoulders and collar-bone, which have to be raised and the muscles of the throat contracted to prevent the breath from rushing out from the upper parts of the lungs. The lower parts of the lungs in this method are never inflated. The column of air is shortened, and, in consequence, too great a pressure is put upon the vocal cords, setting up a hideous tremolo, which, if indulged in for any length, becomes incurable.

Some teachers of singing maintain that it is impossible for women to breathe diaphragmatically, an idea which is erroneous. It may not be possible for them to breathe so deeply as men—and owing to their structure there will always be a wider expansion of the chest—but with patient practice and perseverance every woman is able to breathe in this way.

To breathe diaphragmatically the body must be easy and natural. Both feet should be placed firmly on the ground, with one foot slightly forward bearing the full weight of the body. During practice it is advisable that the student should stand with his hands behind him, lightly resting them on the small of his back.

The shoulders must be kept back naturally and easily, and not be allowed to rise, the point of the shoulder being in a vertical line with the forward foot. When this position becomes strained the rear foot may be brought forward and the weight transferred to it. The chest must be well expanded, yet without drawing down the shoulders unnaturally. The muscles of the throat must be relaxed, the neck quite free and unconstrained, the head slightly forward and erect, not depressed, and the chin kept back, not pushed forward.

Let the mouth assume a smile so that the upper lip is slightly drawn off the teeth; also keep the tongue quite flat.

One of the commonest faults with beginners is the moving of the mouth and chin after the breath has been inhaled. This must be assiduously avoided by the student, who is recommended to practise before a mirror so as to guard against this bad habit.

Let the expression of the eyes be perfectly natural. Keep the eyebows still and the forehead smooth, as there must be no sign of effort or exertion whatsoever.

The following breathing exercises must be practised in pure air, not in a room where the air has been used up. They should never be practised when the body is fatigued, nor immediately after meals, because if the stomach is charged with food the diaphragm cannot work as it should. The best time to practise is in the morning whilst dressing, or about an hour and a half after breakfast. No tight clothing ought to be worn round neck or waist.

Although not absolutely essential, it is certainly advisable that both singers and speakers should keep their nostrils clean and free; this can be easily accomplished by using as a nose bath every morning a tumblerful of tepid water in which has been dissolved a tablespoonful of common salt. Pour a little of this into the hollow of the hand, and sniff it up the nostrils alternately three or four times. All foreign substances are removed in this way, and inhalation is greatly assisted.

Exercises for Inhalation. The first exercise is to inhale very slowly, quietly, and evenly through the mouth, which must be partly open to prevent the air passing through the nose. Place the hands lightly on each side of the body to feel the lower ribs expand. If pressed too heavily, the ribs will be prevented from moving to their fullest extent.

When the ribs are expanded to their utmost mentally count five, then let the breath rush out through the mouth. This ought to produce the sensation of the total collapse of the chest.

When five can be counted with great ease, increase the number to seven, nine, eleven, and thirteen. This exercise should be practised

twenty times a day, at four distinct intervals; it must never be practised twenty times in succession, as it is too fatiguing. It should be noted that the breath should be controlled by the diaphragm and rib muscles only.

To put it concisely, the exercise is this. Breathe slowly, quietly, and evenly through the mouth; hold the breath whilst mentally counting five; let the breath *rush* out through the mouth.

For a second exercise, inhale as in the previous exercise. Hold the breath whilst mentally counting three; re-inhale without allowing any of the first breath to escape; count one, then try and inhale again—that is, three inhalations in all—then let the breath rush out through the mouth. This must not be practised until the first exercise has been completely mastered. It must never be practised more than nine times a day at three distinct intervals. The object of this exercise is to increase the girth of the lower part of the chest.

The next exercise is to inhale through the mouth *quickly* and quietly, mentally counting five whilst holding the breath with the diaphragm and rib muscles; then let the breath *rush* out through the mouth. Gradually increase the number counted. Practise twenty times a day at four distinct intervals. It is possible that the student may make a gasping sound whilst inhaling quickly, but this can be avoided if the soft palate and uvula are raised. On no account must the shoulders be raised.

The fourth exercise is to inhale quickly and quietly. Count three, inhale; count one, inhale again; then let the breath rush out immediately through the mouth. Practise nine times a day at three distinct intervals. Should the sides of the mouth become dry, let the student inhale alternately through the nose and mouth.

Exercises for Exhalation. The first exhalation exercise is most generally used in songs, solfeggio, etc., when the breath has to be taken in hurriedly.

Inhale quickly and quietly through the mouth, hold the breath whilst mentally counting five, then let it pass out slowly and silently; keep the lower ribs expanded as long as possible, and feel that the stomach is very gradually inclining inwards and upwards. Be careful that the upper part of the chest does not move, and guard against puffing out the cheeks. Until the student becomes quite familiar with the movements required it is advisable that he should place one hand on his lower ribs and the other on his chest.

This exercise must not be attempted until the inhalation exercises have been thoroughly mastered. Practise fifteen times a day at three intervals. To express this briefly, take a *quick* quiet breath through the mouth, hold whilst mentally counting five, exhale very slowly.

A Difficult Exercise. We now come to the last exercise. It should always be used at the beginning of a song or solfeggio, or where a phrase is preceded by a rest. The remarks referring to exhalation in the first exercise apply equally to this. It requires very careful and diligent practice, or it will never be perfect.

Inhale slowly and silently through the mouth; mentally count five, and, by degrees, seven, nine, and eleven; exhale *very slowly*, keeping the ribs expanded till the last particle of air is expelled. This must not be practised more that nine times, at three distinct intervals, as it is very fatiguing.

All these exercises must be studied and persevered with in the above order to ensure complete mastery. When this has been accomplished, three of them must still be carefully and regularly practised every day, not only by the novice but also by the advanced student—inhalation, first exercise; exhalation, first exercise; exhalation, second exercise. They must be practised in this order.

Exhalation is controlled entirely by the diaphragm and rib muscles. The student must exert all his will power to prevent the rising of the former and the falling in of the latter after he has expanded the lungs by inhalation. It should be remembered that it is the will alone that can control their movements.

Another exercise of lesser importance, but beneficial to the student, is to inhale slowly, hold the breath whilst mentally counting five, then exhale slowly, counting *aloud* first as far as seven, then ten, increasing the number as he gains control over his breath. He may also recite the letters of the alphabet in the same way, but he must cease counting or reciting before the last particle of breath has expired or the end of the phrase will sound gaspy, and this will be quickly detected by a listener. It has been well said that by observing how a phrase is finished we can tell if the respiration is correct. MARY WILSON

Beet Sugar Growing and Manufacturing Processes. Minor Sources of Sugar. Refining Sugar. The Use of the Polariscope.

BEET SUGAR & ITS MANUFACTURE

SUGAR beet is grown in all the countries of Europe, from Sweden, in the north, to Spain, Italy, and Greece, in the south. It is cultivated in Canada and the United States, Australia, South Africa, Persia, and Siberia. The plant (*Beta vulgaris*) is indigenous to the South of Europe.

Propagation. Beet is propagated from seed. The original beet has been improved by a careful selection of the best sugar-bearers, and judicious and scientific fertilising has evolved beets which contain as much as 18 per cent. of sugar. Vilmorin of Paris was the pioneer in this work of selection, and his successors, Vilmorin, Andrieux & Co., are still recognised as the premier house for beet seed. In England the houses of Sutton and Carter have paid considerable attention to the production of a good sugar-bearing beet, and both sell a good seed suitable for growing in England. Beet giving a large sugar-yield costs no more to grow than beet with a small yield, so that the selection of seed is an important matter to the grower. Illustrations are given of the Vilmorin Improved, the White Silesian, from which the former is descended and sometimes regarded as a distinct species, and the Imperial [7]. Other well-known kinds are the Klein-Wanzleben and Heine's Vilmorin.

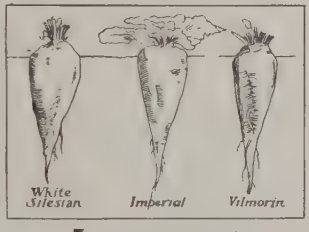
Characteristics of Good Beet. The shape and manner of growing of the beet are important. The most desired characteristics are thus summed up by Newlands :

1. Beets should have a regular, pear-shaped form and smooth skin.

2. They should not have a tendency to throw out forks or fingers and toes.

3. The flesh should be firm and white, the structure uniform, and the flavour "clean." Thin-skinned beets are preferable, as the thick-skinned varieties are frequently spongy and always more watery.

4. The beets should weigh 1½ lb. to 2½ lb. each, because neither very large nor very small roots are profitable to the manufacturer.



7. SUGAR BEETS

5. Good beets have no tendency to become "necky," and their tops are always smaller than those of inferior beets. The large-leaved are preferable to the small-leaved varieties.

6. Good beets are denser than water. The quantity of sugar can be roughly estimated by the density. If the beets sink in a liquid of 1·07 sp. gr., the percentage of sugar is about 14.

7. The roots should grow entirely in the ground in properly prepared soil.

Range of Temperature. Authorities are agreed that temperature has to be considered in beet cultivation, rather than the rainfall. Sugar formation is favourably influenced by dry weather in the autumn. A mean summer temperature of 70° F. for 90 days is sufficient to mature beetroot ; if the temperature be much above this the amount of sugar is diminished. The crop must be matured and safely harvested before the frosts set in.

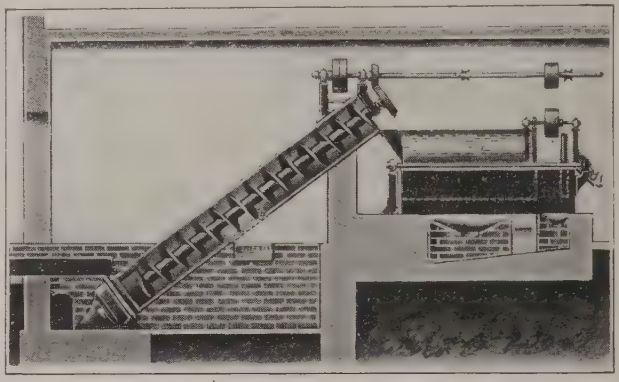
Soil. Any good soil that will grow wheat, and has an arable depth of 12 in. to 15 in., is well suited for beet culture ; it must be well drained. Where a large proportion of chalk is present in the soil, the juice yield of the beet is small but of good quality. In the United States, Dr. H. C. Meyers devoted much time to the study of the growth of beet in alkaline soil such as exists in Utah. Dr. Meyers found that moderate irrigation tends to carry the salts in the soil down to below the plant roots, and that by deep tillage, maintained throughout the season, evaporation and rising of the alkali may be largely prevented. The importance of these observations is that arid regions unsuitable for any other crop may be utilised for beet.

Sowing. In Great Britain, April is the time for sowing beet seed. The frosts should be over, because if the sowing be done too early and the plants become frost-bitten it will be necessary to plough up the first sowing and sow afresh. Some sow the seeds (previously soaked in water for 20 hours) in continuous lines along ridges which have been thrown up from 14 in. to 18 in. apart. The ground should have been stirred up to a depth of 12 in. by the cultivator or subsoil plough, and if manured the manure is ploughed in 5 in. deep. A better way than the continuous line is to dibble the seeds, three in each hole. To keep the beets down to the limits of size—½ lb. to 2½ lb.—they are planted with about 8 in. between the roots, bearing in mind that some of the new kinds of beet with strong foliage require the rows to be up to 20 in. apart instead of the 18 in. limit just referred to. The seedlings are allowed to grow until 3 in. to 4 in. high, and where more than one plant has come up from each hole the weakest are pulled up, and any misses filled up with these plants. The quantity of seed required, if sown in continuous line, is 10 lb. to 15 lb. an acre ; if dibbled in, 5 lb. to 7 lb.

Hoeing. As soon as the plants appear above the ground the soil should be kept loose and free from weeds by hand hoeing. After thinning and until the plants have grown too large, the horse hoe may be used two or three times, its work being finished off each time with a hand hoe. The soil should be earthed up so as to cover the roots. If any plants begin to send up stalks, the stalks should be at once broken off.

Harvesting. The crop must not be harvested until it is ripe, but at the same time it should not be left to be injured by the frost. In from three to seven months the leaves begin to droop and turn yellow, leaving exposed on the top of the root a crown of young green sprouts. As soon as this takes place, the roots are ready to be pulled. If the autumn be cold and dry, the roots

may be left without injury for a week or ten days later, but if the weather be mild and moist new growth would be encouraged, which is undesirable. The roots are pulled by hand labour, but more economically by special harvesters, consisting of a fork on wheels, drawn by horse power. The roots are caught by the prongs of the fork, which pulls them out of the ground and drops them. Care is taken not to puncture or bruise the roots, as this means loss of sugar. The earth is shaken off the roots, the leaves and crown are cut off [11], and the beets then carted to the factory.



8. SCREW CONVEYER FOR ELEVATING BEET

Use of Manures. The use of manure depends on the nature of the soil. It is generally recommended not to manure the beet crop directly, but to manure heavily a preceding cereal crop, and let the residue of manure serve for the beet. With modern artificial manures, however, the amount of manure can be adjusted to actual requirements, making it advantageous to manure the crop directly instead of indirectly. Nitrogenous compounds have a tendency to extend the period of growth and delay the time of ripening. This tendency must be corrected by phosphates. The Victorian Department of Agriculture recommend for light dressing 2 cwt. of sulphate of ammonia and ½ cwt. of superphosphate; for heavy dressing, 4 cwt. of sulphate of ammonia and 1½ cwt. of superphosphate per acre. Where potash is needed, ⅔ cwt. to 1½ cwt. of kainite may be used. The cost is heaviest the first year, because subsequently the refuse of the sugar factory is returned to the land, and goes a good way towards keeping the soil manured.

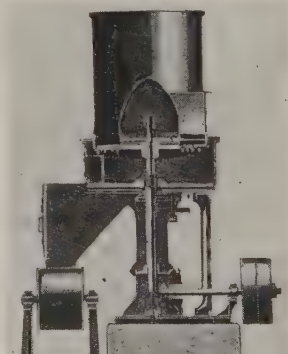
Stable manures must be used either on the preceding cereal crop or worked into the soil in the autumn ploughing. Chile saltpetre or nitrate of soda can be used in place of sulphate of ammonia, and the calcium nitrate produced electrolytically in Norway is equally efficient. [See page 307.]

Diseases. Beet is sometimes attacked by grubs of the beet canon-beetle (*Sulpha opaca*), the beet or mangold fly (*Anthomyia betæ*), and the silver moth (*Plusia gamma*). These are overcome by spraying the upper and under sides of the leaves with Paris-green solution. A disease known as "jaundice" is prevalent in the northern parts of France, and generally makes its appearance during the first fortnight in July. When the plant is first attacked the leaves begin to droop and become mottled with white translucent spots. It has been found that this is due to bacteria, and as the sugar yield is reduced by a half in diseased roots, the refuse from the crop should be burnt before being returned to the land. When stored in silos, a slight loss of sugar takes place, and "greying" of sugar has been directly traced to dry-rot which sometimes sets in during storage.

Yield of Beet. An acre of roots weighing 2 lb. each, and growing 10 in. apart in rows 15 in. apart, would, if there were no misses, yield 40½ tons of dressed roots. The heaviest yield has been 65 tons, and, while 25 to 35 tons may be reckoned as the average, this yield is high according to experimental growing in England.

Cultivation costs are difficult to give with accuracy, as conditions of labour and rents vary in different parts of the country. The average yield of washed roots which has been obtained in Norfolk and Suffolk is 12 tons per acre, and the total average cost of growing (including cultivation, seed, manure, rent and rates) comes out at £9 7s. 6d. per acre. At 25s. per ton (the price in 1914) a crop of 12 tons will give the farmer a return of £15, and a profit of £5 12s. 4d. per acre, less the cost of placing the crop on rail.

Yield of Sugar. The mean sugar content of 1200 samples of beet analysed by Graftian, a Belgian chemist, in 1898, was 16·4 per cent., the extremes being 20·2 and 12·5 per cent. About half the sugar is obtained as *first* sugars, the rest being divided between *second* sugars, *third* sugars, molasses, and losses. The average percentage of water in the beetroot is 77·69, and in the juice extracted 81·51, the average specific gravity of the juice being 1·077.



9. BEET SLICER

In 1879, a Select Committee of the House of Commons was appointed to inquire into the effect produced upon the home and colonial sugar industries of Great Britain by the bounty system in those countries which manufacture sugar for export. One of the witnesses, Mr. James Duncan, stated that Great Britain was adapted for beet cultivation, but that the bounty system of foreign countries, averaging £2 a ton, acted as a preventive of successful production of beet sugar in the British Isles. Dr. Voelcker, chemist to the Royal Agricultural Society, stated that he found 12 per cent. of sugar in roots grown in Suffolk; 12·5 to 13 per cent. in roots from Berkshire; 11·75 in roots from Surrey; 10·5 to 13·25 in roots from Yorkshire, and 10, 12, and 13, up to 15 per cent. in roots from Killarney. Mr. Martineau had roots grown in Lincolnshire and the Isle of Thanet, and obtained 15 per cent. of sugar, compared with the average (at that time) of 10·5 per cent. in France.

Experiments in Great Britain. The factory which Mr. Duncan started was at Lavenham, but the venture was not a success. The quality of the beets improved year by year, but the

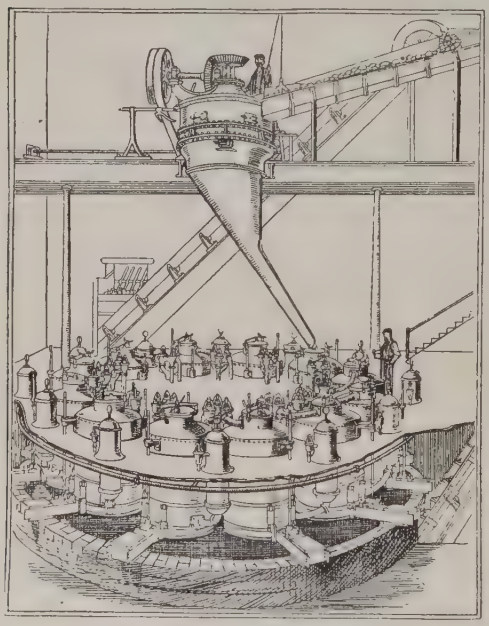
SUGAR BEETS IN ENGLAND AND FRANCE

10. ENGLISH-GROWN BEETROOTS. THOUSANDS OF TONS ON A FARM AT CANTLEY

11. REMOVING LEAVES AND CROWN FROM BEETROOTS DURING HARVESTING IN FRANCE

farmers did not properly modify their rotations to secure a sufficient supply of beets for working at a profit. Sir J. B. Lawes and Sir J. H. Gilbert published, in 1898, a valuable summary on the conclusions they had arrived at as to the growth and manufacture of sugar in the United Kingdom. On the whole, the authors were rather sceptical as to the suitability of England for beet-growing.

England Too Cold. The perfected beetroot grown abroad is supposed to require an average temperature of 70° F., while statistics show that the mean temperature for July, the hottest month in the year, is, in England, only 62·5° F., and for September and October 50° F. and 43·2° F. respectively. These latter are the critical months during which the beet matures and ripens, and, in England, October is nearly always rainy and often frosty. Norfolk or Suffolk they considered most suitable for beet cultivation, the climate being appropriate, and the soil neither too light nor too heavy.



12. CIRCULAR DIFFUSER

Why England should Grow Beet. The late Mr. Sigmund Stein, of Liverpool, for years advocated beet-growing in England. He enumerated the advantages which Great Britain possesses over Continental competitors. (1) We can grow more roots per acre; (2) we can grow richer roots than on the Continent; (3) we have the consumption at hand, since we are the greatest sugar consumers in the world; (4) we save freight; (5) we save commission, as the factory sells direct to the consumer; (6) we can make use of the latest improvements in cultivation and manufacture by having at our disposal the best implements and machinery; (7) we can manufacture refined sugar direct at a very low price; (8) we can employ the plant of our works in the summer months after the campaign is over much better than the factories can do on the Continent, as we have many other industries in this country which could be well carried out in this factory.

Profitable Home Cultivation. Since then experiments have been conducted on a large scale, and at Cantley, near Norwich [**10**], a factory has been built by the Anglo-Netherlands Sugar Corporation which, after uphill work, is now successful financially. The work is encouraged by the absence of any Excise duty on sugar to countervail the Customs duty. The question of the home cultivation became urgent in 1914, owing to the stoppage of supplies of sugar from Germany and Austria, and the production was urged of sugar within the Empire sufficient for the needs of the Empire.

From Beet to Beet Sugar. The outline for the process of manufacturing sugar from beet is as follows: The beets are washed from adhering earth and stones, and then, by means of an elevator, sent up to a machine which slices the beets into pieces resembling vermicelli. The slices are then put into large iron cylinders and "diffused" with hot water, by which means the sugar is obtained in solution. This sugar solution is then mixed with about 2 per cent. of lime, and carbonic acid gas passed into it. A chemical reaction takes place, and carbonate of lime is thrown to the bottom of the vessel, taking with it most of the impurities. The liming is repeated, and sulphurous acid gas passed in. Another precipitate then forms, and leaves a clear liquid, which is evaporated until sugar is thrown out in a similar way to that followed in the case of cane-sugar manufacture. The divisions into which the subject can conveniently be divided are: (1) washing and slicing, (2) diffusion, (3) saturation, (4) evaporation, and (5) crystallisation.

Raising the Beets to the Washers. The beets are conveyed to the washing tanks by bucket elevators, scoop-wheel elevators, or screw conveyers [**8**]. The *bucket* elevator is not much used—at least, in modern factories—as the grit and earth from the beetroot cause a disastrous amount of wear on the buckets and chains. The *scoop-wheel* consists of a long enclosed wheel, with a series of scoops on the circumference. The beets are conveyed down a channel to the bottom of the wheel, and are caught by the bottom scoop. The wheel of scoops revolves, and as each scoop takes up its quantity it passes higher up, and is replaced by the one behind it. When the scoops reach the top of the wheel their contents are automatically thrown into a channel which conveys them to the washing machine. To lift the beets to, say, 18 ft., the wheel requires to be very large and cumbrous; hence, if the distance be more than a few feet, the screw elevator is used. The *screw conveyer* is perhaps the most convenient means of transporting beets, and is also useful for lifting water at the same time. As will be seen from the illustration, the screw conveyer consists of a heavy hollow spindle with a spiral blade, the whole being placed in an inclined position. A screw conveyer about 40 in. diameter and 25 ft. long raises about 600 tons of beets in 24 hours.

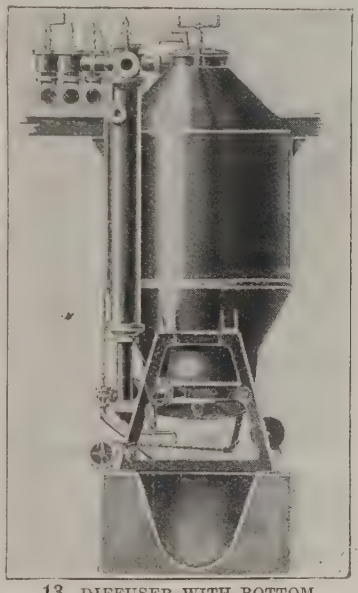
The Washing and Slicing Machines. Washing removes soil and pebbles, which would not only injure the slicers, but introduce much mineral impurity into the subsequent diffusing vessels. The simplest form of beet washer is known as the *whisk* washer. It is fitted with a stirring gear consisting of a central shaft to which vertical arms are attached. The vessel in which the stirring gear is attached is of wrought iron, open at the top, and fitted with a perforated bottom through which earth and stones fall. Underneath the

washing machine there is a discharge arrangement for the water, and the stone trap is fitted with a manhole for cleaning out the stones. Another form of washer consists of a perforated drum, into which the beets are put, and which revolves in a water trough fitted with discharge arrangements like the whisk machine.

After washing, the beets are conveyed by an elevator to the slicing machine on an upper floor. This elevator may be of the bucket variety, in which an endless chain of buckets is employed.

The slicing machines cut up the roots into *cossettes* or slices. A useful pattern is shown in **9**. Extra sets of cutter-boxes and knives should be ordered with the machine.

Diffusion. Formerly the beets were rasped to a pulp, the juice pressed out in hydraulic presses, and the solid mass dried by centrifugal machines. Schützenbach then suggested macerating the dried roots in warm water, but this comparatively slow process was replaced by the diffusion process, on the suggestion of Dubrunfaut. The sliced beet is conveyed to the diffusion battery by a band conveyer. Fig. **12** shows a battery in a series of twelve diffusers arranged in a circular manner, the one shown being fitted up by the Compagnie Fives-Lille. The hopper at the top revolves, and feeds the diffusers in turn with cossettes. Diffusion batteries are also arranged in straight lines of twelve or fourteen diffusers. The method of discharging the diffuser varies, but the bottom discharge for exhausted beets is preferable, as shown in **13**. Dr. Pfeiffer's patent discharge is effected by means of compressed air. As soon as one cell of the diffuser is charged with cossettes, it is shut down, and warm water run in. This water takes up some of the sugar, and is then passed into each of the other diffusers in turn. The smaller cylinders shown outside the circle of diffusers are called *calorisers*, and reheat the water, which, as it passes from the diffusers, loses much of its heat. The exhausted beet is discharged from the diffusers, and is conveyed to a pulp press, where a large proportion of the water is removed, and the residue left ready for cattle food.



13. DIFFUSER WITH BOTTOM DISCHARGE

Continuous Diffusion. In continuous diffusion the diffuser is an iron cylinder, and contains a perforated iron cylinder 4 ft. in diameter and 36 ft. long. The axis is formed by a smaller cylinder, and between the two is a helix. The inner cylinder is revolved at such a rate that beet slices travelling along the helix take about one hour to go the whole length. The cossettes are continually immersed in water, which enters at one end, at 86° F. The conditions for good diffusion are fulfilled when the cossettes and water move in opposite directions.

Saturation. The juice from the diffusers is conveyed to the saturation tanks, where 2 to 3 per cent. of lime is added in the form of milk of lime. The juice is then submitted to carbonic acid gas, this process being called *carbonatation*.

Double and Triple Carbonatation. The precipitate that falls takes down with it many of the impurities in the juice, and the heat that is applied sends up a scum. The clear liquid is decanted, the scums and sediment being filtered in a filter press. The clear juice is again treated with a smaller quantity of lime, carbonic acid gas passed in, and the resulting precipitate again removed. Finally, sulphurous acid gas is passed in, and the sulphide of lime removed by filtration. The clear liquid that results, known as "thin liquor," is next evaporated in a similar manner to cane juice. *Triple carbonatation* is sometimes used, but while it is of great value in practice, it is not considered sufficiently superior to double carbonatation to warrant general use.

Carbonic Acid Gas. The carbonic acid gas used in carbonatation is obtained by roasting limestone. The kilns in which this is done are either separately fired with coke or constructed to deal with coke and lime in alternate layers. The interiors of the kilns are built of firebrick and cased with iron plate. The carbonic acid gas is drawn off through two pipes near the top of the kiln, and the gas is then passed into a cooler and washer. The kilns are charged from the top with lime, or lime and coke. The gas washer is a cylindrical vessel; the gas enters near the bottom and meets a shower of water which falls from near the top of the washer. The gas finally leaves by an outlet at the top of the vessel to be pumped into the beet juice.

Sulphurous Acid Gas. Sulphurous acid gas is given off when sulphur is burnt in the air. It exerts a powerful bleaching effect on the beet juice. Special iron furnaces are made for generating the gas. Sulphur is fed in at the top, and combustion is started by inserting a red-hot iron, and kept up by passing in compressed air. The fumes known as sulphurous acid gas, are pumped direct into the beet juice at the stage indicated above. It is suggested that liquefied sulphurous acid might advantageously replace the gaseous form.

Use of Lime. The quicklime removed from the limekiln is used in the sugar factory for making milk of lime. This is usually done in brick tanks, but special lime-slaking machines are sold for the purpose. Sufficient water is used so that when all action has ceased the lime is still covered with water. Before being used more water is added to make milk of lime. Some workers recommend dry-slaked lime to be added to the beet juice instead of milk of lime, but others allege that darkening of the juice results from using the solid.

Saturation Plant. Carbonatation and sulphuration are carried on in square saturators, either sunk in the floor with working valves controlled from the top, or so arranged that the valves are in the front of the apparatus. The carbonic acid gas is admitted by valves, and there are also provided steam coil, inlet and outlet valves, and

juice valves. Saturation with sulphurous acid gas is conducted in similar saturators, which are connected with the gas supply from the sulphur furnace.

Filter Presses. The horizontal type of filter press, now so largely used, consists of a heavy cast-iron frame, supporting a number of square plates by means of projections on the sides of the plates. The square plates are corrugated on the surface, and upon each plate is placed a filter cloth. A series of these plates is screwed tight together by means of levers, and then the sugar juice is pumped or forced through the press by means of a central conduit. The pressure sends the clear juice through the cloths, leaving the sediment on the cloth in a cake. In another form of filter press now generally preferred the juice enters at the corner of the filter plates. Other types of filters are the Taylor filter [17], the Danek filter, which works at pressure, and the Claritas filter, which is designed for filtration without pressure. Sand filters should also be mentioned, as they are a cheap method of obtaining clear sugar juices.

14. COLLECTING MAPLE SAP

Special machines are made for washing the filter cloths. These consist of a cylinder in which is a revolving shaft carrying paddles.

Extraction of Sugar from Molasses. One of the most important problems in the sugar industry is how best to recover the sugar which remains in the molasses obtained in the manufacture of crystalline sugar from cane or beet. The process usually followed is that of Steffen.

The Steffen Process. Steffen discovered that lime forms with sugar three different saccharates—the *monobasic* saccharate, the *bibasic* saccharate, and the *tribasic* salt. The tribasic saccharate is with difficulty soluble in 200 parts of water, but is quite insoluble in water saturated with the tribasic salt itself. When precipitated under certain well-defined conditions it is granular, and can be readily washed in the filter. The operations in the process are: Forming the bibasic saccharate in the cold; boiling to form sugar and tribasic saccharate; and filtering the tribasic salt. The process is worked as follows: Molasses is diluted with water until it has a density of 6·6° Baumé, equal to from 7 to 8 per cent of sugar. Then, with constant agitation, small quantities of quicklime are added, in the proportion of 1 of lime to 1 of sugar. After each addition of quicklime the temperature rises, and is cooled to 15° C. before adding further portions of lime. The mixture is then filtered in a filter press, and the clear filtrate heated for ten minutes at 100° C. Tribasic saccharate is formed, and is filtered out and washed with hot water to decompose it. The residual lime is precipitated by passing carbonic acid gas into the solution, and the sugar obtained by filtering and evaporating. It is usual, however, to employ the tribasic saccharate instead of lime for treating raw juice. The other liquors are used for diluting further quantities of molasses, and are eventually used as a fertiliser when they become laden with the mineral impurities of the molasses. The Steffen process is equally applicable to the recovery of molasses in refineries, the slight variation involved being in the treatment of the saccharate. The saccharate from the presses passes into the dissolving pans, where it is dissolved by means of sugar syrup which has been saturated with carbonic acid gas and heated to about 70° C.; the sugar solution is then diluted with sweet waters so that it contains approximately 5 per cent. of sugar. After filtration the liquor is fully saturated with carbonic acid gas and treated as above. The processes of concentrating the sugar solution and "curing" the sugar are the same as those given for cane sugar.

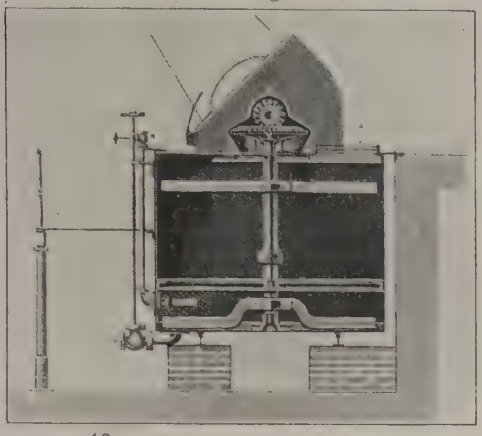
Beet Sugar Factory. The cost of a factory for manufacturing beet sugar may be estimated at from £30,000 to £40,000, this sum providing the machinery for working 300 tons of beetroot a day. The factory building would take about a year to construct and fit, and would cost about £8000. A working capital of about £40,000 is also required for paying for roots and current expenses. Such a factory would purchase beetroots from the growers in the neighbourhood, or the beet-juice is conveyed from a distance by pipe lines. In regard to the general arrangement of the factory the ground floor is usually taken up with the beet-washing apparatus, the diffusion battery, centrifugals, vacuum pumps, beet elevators, boiler-house, limekiln, and bone-black filters. On the next floor are the carbonatation apparatus, the triple effet, upper part of diffusion apparatus, beet elevator, and laboratory, while on the upper floor are the vacuum pans. Rooms are provided for storing sugar and packing purposes.

15. SORGHUM

The Waste Products of Sugar Factories. The *bagasse* of cane-sugar factories is utilised as a fuel for generating motive power, and is also employed for paper-making, and as manure. Special furnaces are required for burning bagasse. Dry cane leaves (trash) are only slightly inferior to bagasse as fuel. Bagasse wet from the mill is commonly regarded as being equivalent in fuel value to from one-fifth to one-sixth of its weight in coal. Bagasse has also been proposed as a food for cattle.

Molasses is used as a fuel, for the manufacture of alcohol, and for feeding cattle. One method of using it as fuel is to sprinkle the molasses on the bagasse on its way to the furnace, or it can be sprayed on the burning bagasse. Animals take molasses fodder willingly, and no bad effect has been observed, or purgative action has been noted, and the quantity of milk in the cow fed on molasses fodder is increased, though it does not keep so well. Organic acids specially suited for mordanting wool have been made from *vinasse* or molasses residue.

Dried *diffusion pulp* from beet-sugar making should be dried before being used as a cattle food, otherwise it tends to bring on certain diseases. *Beet tops* are used for feeding cattle, or left to rot



16. MELTING OR BLOW-UP PAN

a. Charging opening *b*. Steam valve *c*. Steam injector for heating *d*. Discharge valve

in the field as manure. The *waste liquors* from beet-sugar factories have also been used as a source of ammonia.

MINOR SOURCES OF SUGAR

Palm Sugar. In India, besides the sugar cane, several palms are used as sources of sugar. The chief kinds are :

Palmyra palm or crab tree—botanical name, *Borassus flabelliformis.*

Indian date palm—botanical name, *Phœnix Sylvestris.*

Sago palm—botanical name, *Caryota urens.*

Coconut palm—botanical name, *Cocos nucifera.*

Neem tree—botanical name, *Melia azadirachta.*

The sap of these trees contains a good proportion of sugar, and it is this juice evaporated which forms the raw sugar. The sap is obtained from the Palmyra palm by slicing off the end of the flower stalk, and attaching to the stalk a little earthenware vessel to receive the sap. In the case of the date palm, incisions are made in the trunk at the place from which the lateral leaves have been removed.

Maple Sugar. Maple sugar is the produce of several kinds of maple-trees, the following being the chief varieties :

Sugar maple, hard maple, or rock maple—botanical names, *Acer barbatum, Michx., A. saccharinum Wang.*

Silver maple, soft maple, white maple, or swamp maple—botanical names, *A. saccharinum Linn, A. dasycarpum Ehrh.*

Red maple, soft maple, or swamp maple—botanical name, *A. rubrum Linn.*

Black maple—botanical names, *A. barbatum nigrum Sarg., A. saccharinum nigrum T. and G., A. nigrum Michx.*

Maple sugar and syrup are much prized in the countries of production—Canada and the United States—on account of their delicate flavour. The sugar is contained in the sap, and the trees are tapped from the middle of February to late in March. A hole three inches deep is bored into the trunk, and into this a tap is driven. The tap is provided with a hook, upon which is hung a bucket, as shown in the illustration [**14**], into which the sap flows. The process of obtaining sugar from maple sap is extremely simple, on account of its purity and freedom from extraneous matter. The contents of the sap buckets are emptied into a tank in the boiling "shop," and from this tank the sap is led to the evaporator, which is heated by prunings of the maple grove. If the maple sugar be required in the form of syrup, which saves much time and fuel, it is evaporated to a density of 1·325 or 11 lb. of sugar to the gallon, and poured while hot into perfectly clean pans or tins, which are then sealed to keep out the air. If made into sugar, the syrup is boiled over a brisk wood fire, in a pan smaller than the evaporator, to a concentration which will crystallise into sugar on cooling.

Sorghum Sugar. Broom corn, Chinese sugar cane, Imphee or Sorgho—botanical name, *Sorghum saccharatum Pers.*—is a graminaceous plant which has been the subject of much experiment as a sugar producer [**15**].

To obtain sugar from the sorghum, the stalks are passed through rollers, as in the case of the sugar cane. The juice is then limed, defecated, sulphured, and concentrated in much the same way as for Beet Sugar. Sorghum syrup is also prepared, in which case a little superphosphate of lime is added to the juice, to ensure a clear and brilliant syrup.

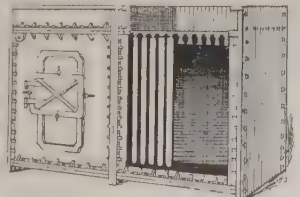
Maize Sugar. The stalks of Indian corn, *zea mays*, contain from 9 per cent. to 12 per cent. of sugar, and are used as a source of sugar.

Melon Sugar. Melons contain about 7 per cent. of sugar, and in California, where the melons grow prolifically on reclaimed land, syrup is produced in large quantities.

REFINING SUGAR

The term *refined sugar* is used for those finer qualities which are made from raw sugar, either cane or beet, at central refineries, and in which animal charcoal has been used for decolorising. Sugar refining is mainly a mechanical process, and consists, briefly, in dissolving the raw sugar in water, filtering through cloth to take out suspended matter, and then through animal charcoal to remove colour. The clear bright liquid is finally evaporated and boiled to crystallisation.

Preliminary Treatment. The raw sugar is usually submitted to a preliminary treatment before the first stage. It is mixed with a small quantity of syrup, put into a centrifugal apparatus, and washed with steam until the syrup flowing from the centrifuge comes away of a light colour. Raw sugar may be said to consist of sugar crystals and molasses, and by washing out the latter the purity of the sugar is at once raised by this treatment. The process separates the raw sugar into partly refined crystals and washings containing a good proportion of the molasses.



17. TAYLOR FILTER

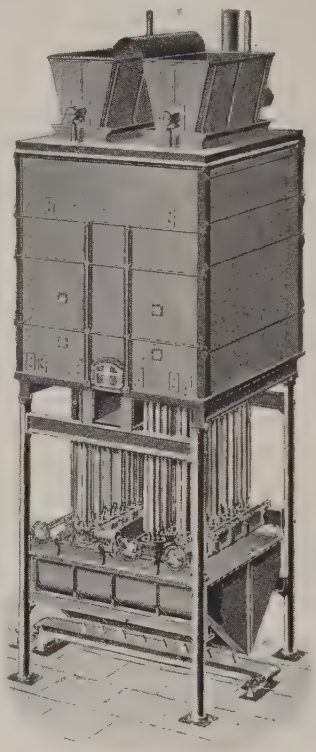
Melting. The partly refined sugar is dissolved in water, or, as it is termed, *melted*, the melting-pans, holding 3 tons to 10 tons, being known as *blow-ups*. The sugar is passed through a grating into the blow-up, which is provided with a false bottom, stirring gear, and heating arrangement either of copper coils or for live steam [**16**]. Here the sugar is melted at a temperature of

150° F. to 170° F. to a syrup of 28° Baumé, and is then filtered.

Filtration. Most refineries in Great Britain use the old Taylor bag or stocking filter [17] for clearing the liquor produced above, although the Danek filter is a favourite on the Continent. The filter presses described under Beet Sugar Manufacture are also used, but not to any great extent, as they are not so suitable for cane syrup. The Taylor filter consists of a large iron chamber with tightly fitting doors in the front. At the top is the tank or filter head, leading to a series of metal sockets to which long filter bags are attached. These bags are made of twilled cotton measuring 6 ft. long and 2 ft. to 3 ft. wide when opened out. The bags are put into sheaths of coarser material, and, the sheaths being smaller than the bags, a larger filtering surface is ensured. The bags are securely fastened on to the nozzles, and hang inside the chamber, which is fitted with steam heating appliances. A filter chamber contains 200 to 500 of the filter bags, and each bag can be separately controlled by plugging the hole leading to it from the filter head, this being necessary when one of the bags turns out to be defective.

The liquor from the blow-ups is run on to the filter head, and passes into the bags, the temperature being maintained by letting steam into the filter chamber. When the bags become blocked up with dirt the liquid ceases to pass, the supply of liquid is cut off, and the bags allowed to drain. The bags are then detached, and washed systematically in several tanks of warm water, the washings being reserved on account of the sugar they contain and run into the *sweet-water* tank.

Decoloration. From the Taylor filter the bright liquid is passed to large *char cisterns*. These are iron towers from 18 ft. to 50 ft. high, filled with animal charcoal or char. The bottom of the char cistern is a perforated plate covered with a blanket, and on this the char is packed to within a short distance of the top. The bright liquor, still warm, is allowed to flow in at the top, and, when full of liquid, the bottom cock is turned off and the whole left to "settle" for some hours. A char filter holding 20 tons of char has room, in addition, for about 10 tons of liquor. After a few hours the cock at the bottom is opened, and the liquor, now free from colour, drains away. More liquor is slowly introduced, until the filtrate becomes tinted, when the stream of liquid is passed into a separate vessel for a lower-grade product. This is continued until the colour shows that the char has ceased to work, when the supply of liquor at the top is cut off, and what remains in the char cistern drained off; the char is then washed with hot water, and the washings run into the sweet-water tank as long as they show the presence of notable quantities of sugar. The char is in this way washed till the water runs clear, when it is allowed to drain, and the char taken out and revivified by burning. In place of animal charcoal the use of new substances, such as "Eponite" and "Norit," has been proposed.



18. CHAR REVIVIFYING KILN
(J. Buchanan & Son, Liverpool)

Reburning Char. The revivification of the charcoal is effected in pipe kilns [18]. The *pipe kiln* consists of a series of cast-iron pipes into which the char is placed and heat applied to the outside of the pipes. The kilns are heated either by direct coke firing or by gas, the advantages of the latter method being that there is an economy of fuel, absence of ashes, and greater uniformity in heating. Beneath the kiln pipes are corresponding cooling pipes. The char is brought to the kilns wet, and is first dried and then, having been filled into the kiln pipes, is heated red hot. The char is next passed to the cooling pipes beneath by means of discharge valves, the contents of the cooling pipes being passed to a hopper, and from this taken to the char cistern for use again.

Boiling down is effected in the multiple-effet apparatus and vacuum pans which were described in the chapter on cane sugar manufacture.

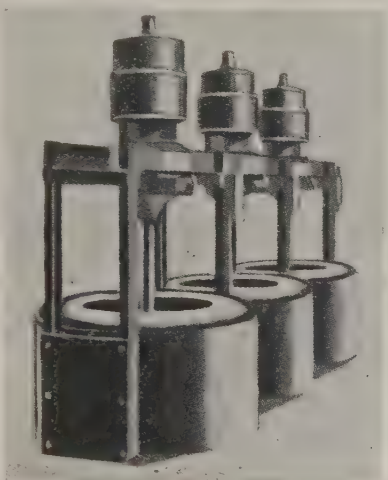
Crystallisation in Motion. In this method the massecuite from the pan is run into the apparatus, which takes the form of a large cylinder, and is kept in very slow movement by a stirring arrangement. In most cases hot water is circulated in the outer vessel to control the cooling, and in some cases the vessel is airtight and worked under a partial vacuum, air pressure being utilised to empty the pan when finished. The process prevents the formation of small grain by inducing the crystallisable parts of the massecuite to grow on crystals already formed or introduced. In the latter case the crystals are brought up to the temperature of the massecuite before being added. The advantage of having large crystals over small ones is that the separation of molasses in the centrifugal machines is much facilitated.

The method is used in beet-sugar manufacture as well as for residual products of the refinery.

Centrifugal Machines. When sugar is to be *machined* it is run from the vacuum pan into a heater fitted with stirring gear. From this it is placed into the baskets of centrifugal machines which, when revolved at a high speed, throw out the syrup. The sugar is more or less washed, discharged into bins, air dried, and packed in bags holding 2 cwt., for sale. The syrups and washings are collected separately; from the syrups another crop of crystals is obtained, while the washings, being purer, are boiled up with the liquors used for producing first product sugar. The centrifugal machine, also known as the *turbine*, to which reference has been made [19], is an apparatus which by water, belt, or electrical driving is spun at a rate varying from 500 to 1200 revolutions a minute. It is arranged for discharging the contents at the top or bottom, and has washing or steaming

appliances. Superheated steam is used in the Baker process. The basket into which the sugar is placed is made of perforated metal, the revolution of the basket causing the mass of crystals and molasses to be violently thrown against the inner wall; the molasses and a portion of the crystals pass through the perforations, but the greater part of the crystals are retained in the basket. Centrifugals are either driven or suspended, the latter type being used more. The size of the basket is 30 in. diameter, but a larger size of 48 in. diameter is in use which, although economising labour, takes more power to drive.

Loaf Sugar. The oldest form of refined sugar is the sugar loaf. To make these the massecuite is formed with a small grain, run into a heater and raised to between 180° and 190° F. From this the mass is run into conical iron moulds, which have a small hole at the top or cone, and a series of moulds is placed cone-downwards in a supporting frame. The hole at the bottom is stopped up with a wooden spike. When the sugar has been partly solidified the contents of the mould are mixed up with a "brushing off" hook with the object of making the texture throughout the loaf even. The moulds remain in the filling-house for 10 or 12 hours, and by that time the contents have become solid. Next, the moulds are removed to a warm room, the plugs in the cones removed, and "green" syrup drips from the mould for about 24 hours. A process known as *liquoring* then takes place. The top surface of the sugar is removed, mixed with syrup (*white liquor*, *cleare*, or *clairce*), and replaced. White liquor is then fed on to the top of the loaf and drains from the cone, taking with it any coloured impurities that remain in the sugar. The liquoring is repeated several times, blued water being used for the final liquoring until the runnings are quite clear and the loaves of uniform whiteness. The loaves are eventually taken out of the moulds, dried in racks, and wrapped up in thick paper. The process takes about a fortnight. The blued water referred to above is prepared from pure ultramarine, or a dye such as indanthrene blue, the purpose of the slight addition of blue being to correct any remaining tint of yellow.



19. CENTRIFUGAL MACHINES
(Watson, Laidlaw & Co., Glasgow)

Cube Sugar. The slowness of the method of making sugar loaves led inventors to study the question of how to make cube sugar in a quicker manner. Many inventions to this end, which involve similar principles, have been patented. The massecuite is boiled to small grain and filled into divided moulds of such a size that a plate of sugar is produced. The moulds are either a kind of centrifugal basket or contrived to fit into the centrifugal basket. The massecuite is cooled in the mould, during which process the crystals are joined together by a secondary crystallisation. The cooled moulds are then put in the centrifugal and the syrup spun out. The plates are also washed with clairce, which is in turn spun out. The moulds are removed and taken apart, the plates of sugar being separated and dried in a special store in a current of hot air. When the plates of sugar are dry, they are cut up into cubes in machines invented for the purpose. The Adant cube-sugar process is worked on the above lines.

Granulated Sugar. Granulated sugar is produced by the Hersey process, patented in 1873. The granulator consists of an outer conveyer cylinder 23 ft. long, 6 ft. diameter, inside which is a smaller cylinder 23 ft. long and 30 in. diameter, arranged to revolve about five times in a minute, and heated internally by steam. The granulator is inclined from the horizontal position, so that sugar introduced at one end travels mechanically to the lower end. A current of air is passed or driven through the drying chambers to absorb the moisture that arises from the sugar during its passage through the granulator. Sugar is first washed in a centrifuge, and then passed through the granulator, about 30 barrels of sugar being treated in an hour.

Other Methods of Refining. Alcohol was suggested for refining sugar by Duncan and Newlands as long ago as 1878, but the fiscal difficulties involved in the use of alcohol are insurmountable. In Langan's process the raw sugar is mixed with a saturated syrup so as to make a kind of artificial massecuite. The mass is drawn into a vacuum pan for the removal of small grain and any contained air. The mass is boiled to form a natural massecuite, then cooled in crystallisers to about 49° C., and subjected to a systematic washing and liquoring with saturated syrup to increase the purity. The sugar is then dissolved in the washing receptacle itself by means of a special appliance.

Fontenille & Desormeaux's Process. The Fontenille and Desormeaux process was patented in 1898, and is worked in the following stages:

1. Melt the raw sugar at a temperature of from 70° to 75°C. and at a density of about 28° Baumé.
2. Add finely powdered animal charcoal in the proportion of from 5 to 40 per cent. of the raw sugar, and mix at above temperature until the colour is discharged from the sugar.
3. Filter in press-filter, or separate the sugar in a centrifugal machine, the charcoal being recovered and washed.
4. Reheat the syrup to 75° C.
5. Pass the syrup through bag filters under pressure.
6. Concentrate and boil to grain.
7. Pass the massecuite into moulds or crystallising apparatus, or submit to centrifugal action. If poured into moulds, only one cleansing is required; if into a crystallising apparatus, the syrup is sucked away by the vacuum, and one cleansing only is needed. When the centrifugal method is used the mass is cleansed in the centrifuge.
8. The mass from the crystallising apparatus, or centrifuge, is broken up and sifted, and then sent to the moulding machine after moistening with 2 or 3 per cent. of blue water.
9. The moulding machine forms the pieces of the size required for sale by pressing. The pieces are expelled mechanically.

10. The pieces are dried in a store at 60° C., either in air or vacuum.

Crosfield and Stein's Process. The Crossfield and Stein process depends on the treatment of the acid solution of sugar with a bleaching agent known as peroxide of hydrogen.

The raw sugar is melted at about 160° F., and the acidity brought up to about 0·02 per cent. with phosphoric acid. The acid sugar liquor at about 27° Baumé, and at a temperature of 180° F., is treated with 0·01 to 1 per cent. of sulphate of alumina, and subsequently with 0·005 to 0·6 per cent. of tannic acid ; then with 0·05 to 0·2 per cent. of phosphoric acid, this treatment partly destroying the colour. Where deemed necessary the liquor may be treated with sulphurous acid. The liquor is next filtered, and the filtrate is treated with 0·01 to 1 per cent. of peroxide of hydrogen, and phosphate of soda or ammonia in quantities of about 0·005 to 0·2 per cent.

The liquor is passed through a filter press, and the clear, bright solution boiled to crystals in a vacuum pan. The massecuite, which is very white and bright, is machined in centrifugal machines and washed therein with concentrated syrup, or, if desired, sugar solution and peroxide of hydrogen.

Robin-Langlois Process. By the Robin-Langlois method the fibres and dust in the sugar are removed by blowing air across a stream of sugar falling from a hopper on to a series of inclined boards. The sugar is then crushed and treated with steam in order to introduce a definite small proportion of moisture, and to brighten the facets of the small crystals. This operation is performed in the mixer for the sake of uniformity. Jets of steam or atomised water impinge against angle plates, whence they rebound on to the sugar, falling from the supply tube into the mixer in two streams.

The *mixer* is essentially an annular space between two concentric hot-water jackets, the rotating blades and sugar being contained in this space at a desired high temperature. The discharge hole of the mixer stands above an annular trough in a revolving circular table, the circumference of the two machines intersecting to the necessary extent.

The circular table contains on its periphery a trough across which the moulds are arranged radially in juxtaposed boxes. These moulds are open at the top, and have perforated bottoms. They are locked, disengaged, and opened by special appliances which enable them to work continuously and to be emptied without injury to the bars of sugar. As the annular series of moulds revolve, they pass in turn under the discharge hole of the mixer, and are filled with sugar by inclined scrapers ; they then pass on, and the sugar in each mould is compressed by a corrugated roller fixed in relation to the table, but revolving on its own axis, so that its projections correspond consecutively with each mould. At a further stage of the revolution the moulds are automatically placed under vacuum and the syrup sucked out, and when dry they are unlocked, emptied, and readjusted continuously by the devices mentioned above.

In the La Fontaine method the patentee applies the reducing agent—sulphurous acid—to the massecuite instead of the raw juice.

And in the Ranson process the syrup is made alkaline with barium hydrate or sodium carbonate, and hydrogen peroxide added in the proportion of from ½ litre to 5 litres per 100 kilos of sugar, according to the colour of the product.

Treacle and Golden Syrup. When the syrups no longer yield sugar they are made into treacle, golden syrup, or invert sugar. Golden syrup is a purer kind of treacle. Of late years the quality has much improved, the appearance in many cases being artificially improved by the addition of glucose syrup. Glucose syrup is also used to prevent granulation, but, in the opinion of some experts, is not necessary if the sugar syrup be well inverted, which is done by treating it with acid.

SUGAR ANALYSIS

The chief analytical operations required deal with the density of juices and syrups, the amount of sugar in a given sample of sugar, the proportion of glucose or uncrystallisable sugar, the moisture, the soluble and insoluble ash, and the rendement.

Density. Density is conveniently taken by means of an instrument known as a *hydrometer* [see pages 611 and 613], the method in which a specific-gravity bottle is employed being too lengthy for general use. The two hydrometers in ordinary use are the Baumé and the Brix, or Balling. The latter is preferred, as the graduations of the scale give close approximations to the percentage of total solids present ; 10° Brix, for example, in a clean juice indicates 10 per cent. of sugar.

Schmidt and Haensch's Polariscope. The amount of sugar in raw sugar is determined by the *polariscope* [see page 2718], the degree of polarisation being the basis upon which sugar is bought and Customs duty levied.

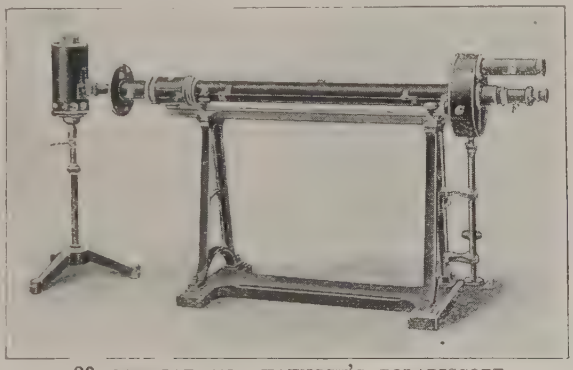
Of the several types of polariscope the *half-shadow* instrument is the one preferred. The principal feature of this type is the division of the circular field of vision into two halves. When the vernier is placed at zero the two halves of the field are uniform in shade. If an observation tube be filled with an optically active liquid, such as a solution of sugar, and placed between the polariser and analyser, the equilibrium is destroyed, the result being that one half of the field becomes dark and the other half bright ; the analyser is then turned to the right of the right half beshaded, or to the left of the left half beshaded, until the field is once more of a uniform shade ; the rotation is then read from the scale.

The form of polariscope or saccharimeter in use in the British Customs Department and the United States Internal Revenue Bureau is that of Schmidt and Haensch [**20**]. This instrument is adapted for use with white light illumination from coal-gas. It is convenient and easy to read, requiring no delicate discrimination of colours by the observer. It is adjusted to the Ventzke scale, which may be defined as "such that the degree of the scale is one-hundredth part of the rotation produced in the plane of polarisation of white light in a column 200 mm. long by a standard solution of chemically pure sucrose at 17·5° C., the standard length of the sucrose in distilled water being such as to contain at 17·5° C. in 100 Mohr's c.c. 26·048 grammes of sucrose." The instrument should be adjusted by means of control quartz plates, three different plates being used for comparative adjustments, reading approximately 100, 90, and 80 degrees on the scale respectively.

A Description of the Polariscope. The illustration [**20**] shows the best form of this polariscope. The tube B contains the illuminating system of lenses ; the polarising prism is at P, and the analysing prism at G. F carries a small telescope, through which the field of the instrument is viewed, and just above is the reading tube M, which is provided with a mirror and magnifying lens for reading the scale. The tube containing the sugar solution is marked R To

use the instrument the operator seats himself with his eye level with the tube F, which tube is moved in and out until the proper focus is secured so as to give a clearly defined image, when the field of the instrument will appear as a red luminous disc, divided into two halves by a vertical line passing through the centre, and darker on one half of the disc than on the other. If, now, the milled head A be rotated first one way and then the other, the appearance of the field changes, and at a certain point the dark half becomes light and the light half dark. By rotating the milled head delicately backwards and forwards over this point, the exact position when the field is neutral or of the same intensity of light in both halves can be found. When the milled head is set at the point which gives the appearance of the centre disc in figure the eye of the observer is raised to the reading tube M, and the position on the scale noted. On each side of the zero line of the vernier a space corresponding to nine divisions of the movable scale is divided into ten equal parts, enabling fractional parts of a degree to be indicated.

Method of Manipulation. Begin by weighing out 26·048 grammes of sugar, dissolving it, clarifying the solution, making it up to standard volume (100 c.c.), and filtering and filling the observation tube, regulating the illumination and making the polariscope reading. The sugar is conveniently weighed in a counterpoised nickel flask with a large lip, whence it is readily washed into the flask. The solution, before being filled up to the mark, is clarified by the addition of lead subacetate or phospho-tungstic acid until no further precipitate takes place. Filtration and clarification may often be made easier by adding a few drops of suspended aluminic hydrate after the lead. The flask is filled with pure water until the lower line of the meniscus coincides with the mark on the neck. The mouth of the flask is closed and its contents well shaken and poured on to a folded filter; the first few cubic centimetres of the filtrate are rejected. The subsequent filtrate, if not perfectly clear, is returned to the filter until it shows no cloudiness. The polariscope tube is then filled and placed in the polariscope, the scale of which, after neutralising the rotation produced by the sugar by turning the analytical prism of moving the quartz wedge, will give the percentage of sucrose in the sample taken. A dark solution may either be read in a 100 mm. tube or decolorised by bone-black. A weak solution may be read in a longer tube.



20. SCHMIDT AND HAENSCH'S POLARISCOPE

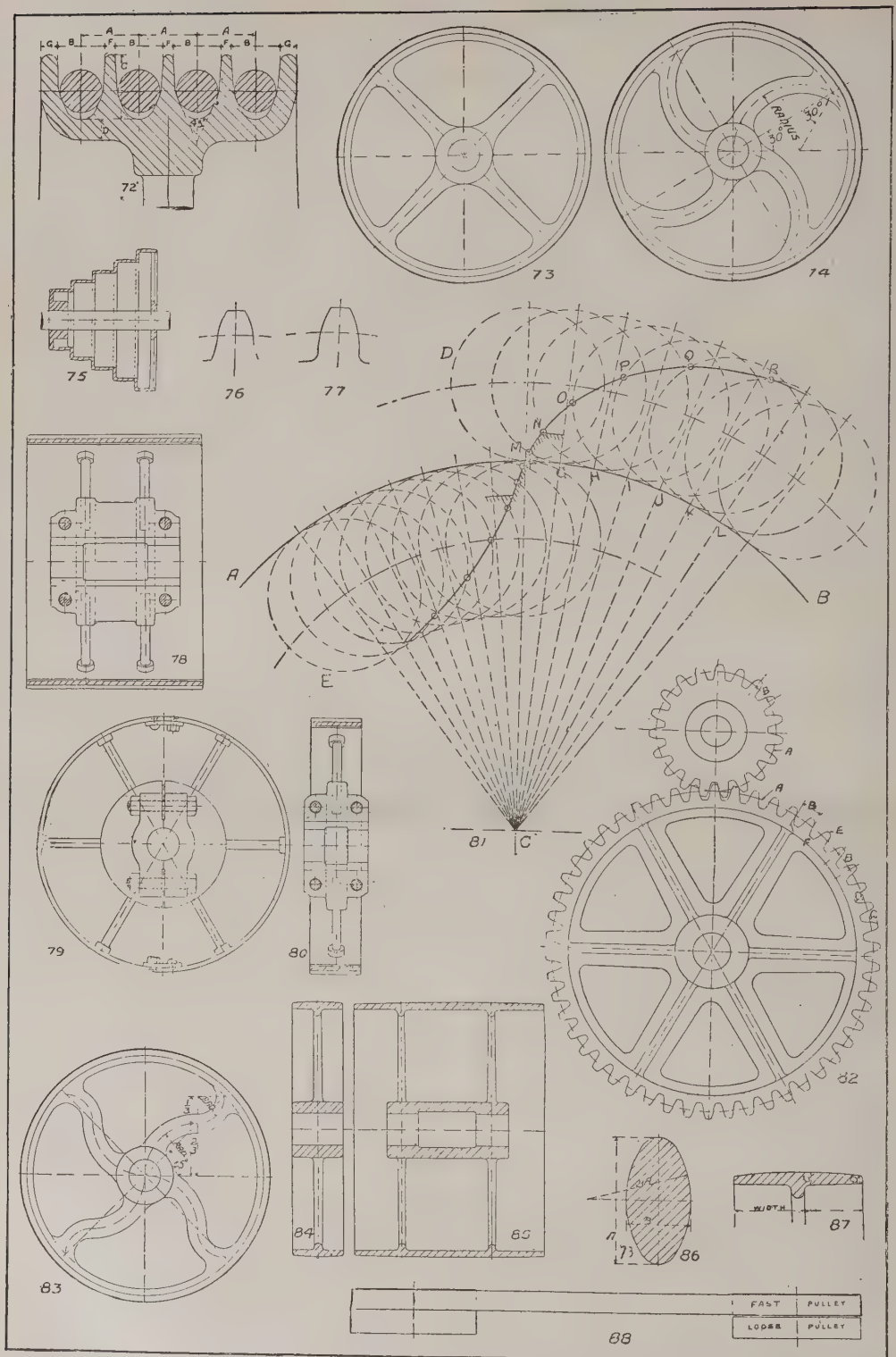
Estimation of Glucose. The reagent required for estimating reducing sugar is known as *Fehling's solution*. Take 34·64 grammes of pure crystallised sulphate of copper, and dissolve it in 200 c.c. of distilled water. Also take 187 grammes of tartrate of soda and potash and 78 grammes of caustic soda, and dissolve in 500 c.c. of distilled water. Add the copper solution to the second solution, and make up to 1000 c.c. with distilled water. The copper in 10 c.c. of this solution is completely reduced by 0·05 gramme of glucose, which is shown by the blue copper solution turning red and throwing down a precipitate of red copper oxide. To make the estimation, place 10 c.c. of the Fehling solution in a flask over a Bunsen burner, and make it boil. Then from a graduated tube (burette) run in a few cubic centimetres of the sugar solution, again boil, and note if any blue colour remain in the liquid. If there be some blue liquid over the red precipitate, run in more sugar solution until all the blue colour has disappeared. From the number of cubic centimetres of sugar solution required, the amount of glucose is determined by calculation. The best results are obtained when not less than 10 c.c. or more than 50 c.c. of sugar solution are needed for 100 c.c. of Fehling solution, and after making a rough estimation the strength of the solution is adjusted to conform with these requirements. The strength of the copper solution can be checked or standardised by comparing it with a solution of pure invert sugar, prepared by heating cane-sugar solution, with a few drops of sulphuric acid to invert it.

Moisture. Weigh from two to five grammes of the sugar into a flat-bottomed nickel or platinum dish, and dry at a temperature of 100° C. for three hours. Cool in a desiccator and weigh: return to the oven and dry for an hour. If, on weighing, there be only a slight change in weight, the process may be considered finished; otherwise the drying must be continued until the loss of water in one hour is not greater than 0·20 per cent. From the quantity of loss of weight of the sample taken the amount of moisture or water is calculated.

Ash. Take five or ten grammes of sugar in a platinum dish, heat at 100° C. until the water is expelled to allow the action to take place slowly, and finally heat in a muffle to low redness. Then, by weighing the ash that is left, the percentage of ash in the sample is obtained. The quantity of soluble ash is estimated by digesting the ash with water, filtering through a Gooch crucible, washing with hot water, drying the residue at 100° C., and weighing. The difference in weight from the above determination equals the soluble ash.

Rendement. Rendement is the French term for the net amount of sugar in a given sample of raw sugar. It is deduced from the fact that each 1 per cent. of ash in the raw sugar prevents 5 per cent. of sugar from crystallising, and each 1 per cent. of glucose causes an equal amount of sugar to be retained in the molasses. Hence, from the amount of sucrose shown by the polarimeter deduct five times the weight of ash plus the weight of the glucose present, and the refining value or rendement is obtained. For instance, a sample of sugar polarised 93 per cent., the glucose was 2 per cent. and the ash 1 per cent., $93 - (1 \times 5 + 2) = 86$ per cent. of available sugar.

There are many alternative methods of analysing sugar, but the above processes are representative of those employed commercially.



72-88. DIAGRAMS OF PULLEYS AND TOOTHED GEARS

72. Rope wheel grooves; **73.** Straight arm cast-iron pulley; **74.** Single curved arm cast-iron pulley; **75.** Section of large cone pulleys; **76.** Double curve tooth; **77.** Single curve tooth; **79.** Wrought-iron pulley, of which **78** is section of a double arm, and **80** a section of a single arm; **81.** Cycloidal curve; **82.** Spur wheel and pinion; **83.** Double curved arm cast-iron pulley; **84-5.** Sections **73, 74,** and **83.** **86.** Section of cast-iron pulley arm; **87.** Section of cast-iron pulley rim; **88.** Fast and loose pulleys

Designs of Pulleys, Rope Wheels, Gears and Gear Teeth, Chains, Cones, and Clutches.

DRAWINGS FOR PULLEYS AND GEARS

Pulleys. Pulleys are made either of cast iron, mild steel, or wood. Cast-iron pulleys may have straight arms, as **73**, single curved arms, as **74**, or double curved arms, as **83**; sectional views are given in **84** and **85**. The object in making the arms curved is to ensure a safe casting, since a straight arm does not yield so readily to accommodate the unequal contraction of rim and boss when the casting cools. The usual section of pulley arm is oval, as **86**, and it tapers from the boss to the rim. The forces acting on the arms tend to break them off, as in the case of the railway axle. The bending movement is found by multiplying the driving force on the rim of the pulley by the radial length of the arm, and dividing by the number of arms. The modulus of an oval section is $= \frac{3{\cdot}1416}{32} \times BA^2$, where A is the depth and B is the width of the section, and a safe stress for cast-iron pulleys is 2000 lb. per square inch. Pulleys are, to a large extent, standard articles, and are manufactured for stock; consequently they are made to cover a wide range of loads. The number of arms may be four for pulleys up to say, 24 in. diameter, and six for pulleys above 24 in. Looking at the sections **84** and **85**, single arms are used up to 12 in. wide and double arms up to 20 in. wide. The length of the boss may be one and a half to two and a half times the diameter of the shaft, while the thickness may be ·45 times the diameter of the shaft; the boss and the inside of the rim should taper slightly, in order to facilitate moulding. The rim of a pulley is slightly rounded, as shown in **87**. A belt will run on a *flat-faced* pulley, but is safer when running on a *convex surface;* flat-faced pulleys are used in cases where the belt is to be moved sideways from a fast pulley to a loose one, as in **88**, which represents a common device used for starting and stopping countershafts in connection with machine tools, etc.

Wrought-iron and Steel Pulleys. A wrought-iron pulley, shown in **78**, **79**, and **80**, is built in halves, and consists of a cast-iron boss and wrought-iron or steel arms and rim. The boss may be cast with the arms placed in position in the mould, or, alternatively, the latter may be screwed and tapped into the boss; the outer ends of the arms have solid collars, and are cold-riveted into the rim; a joint plate is fitted where the half rims meet. Cast-iron pulleys are also made in halves in a similar manner, but flanges are cast under the rims instead of using joint plates. The number of arms in a wrought-iron pulley varies from six to twelve, according to diameter and thickness of rim; double arms [**78**] are used with this class of pulley when a width of 9 in. is exceeded; the diameter of the arm varies from $\frac{1}{2}$ in. to $\frac{7}{8}$ in. These pulleys are generally made with a flat rim, but they can be machined to a convex surface.

A pressed-steel pulley has the arms and rim cold-pressed into shape from steel plates; the arms are dished in cross section, in order to give side stiffness, and also at the end, where they are attached to the boss in order to relieve the rivets from shearing forces. An interlocking plate is riveted between the arms, where they are attached to the rim; this plate enters the rim and so helps the two outer rivets. The rim is curved on the face, and is formed with the edges bent round so as to combine stiffness with lightness; in some cases the rim is doubled on itself, so as to give a specially strong rim for extra heavy duty. The boss and rim are in halves, and are bolted together.

Relative Speeds of Pulleys. A belt may not only be regarded as an agent for the transmission of power, but also as a means of giving a certain speed to a shaft. Taking the case of a belt drive where both pulleys have the same diameter, as **89**, it is evident that both shafts will revolve at the same speed if "slip" is neglected; but if it be desired to drive one shaft at twice the speed of the other, then one of the pulleys must be twice the diameter of the other; the circumferential speed of both pulleys remains the same, but the smaller one, having half the circumferential length of the other, makes two revolutions to the other's one. The following rules may be deduced from the above principle:

To find the diameter of a driven pulley to give a certain speed to a shaft, the diameter and speed of the driving pulley being known.

Rule: Multiply the diameter of the driving pulley by its speed in revolutions per minute, and divide the result by the required speed of the driven shaft in revolutions per minute.

To find the speed of a driven shaft, having the diameters of both pulleys given as well as the speed of the driver.

Rule: Multiply the diameter of the driving pulley by its speed in revolutions per minute, and divide the result by the diameter of the driven pulley.

To find the diameter of a driving pulley, the diameter of the driven pulley and the speeds of both being given.

Rule: Multiply the diameter of the driven pulley by its speed in revolutions per minute, and divide the result by the speed of the driving shaft in revolutions per minute.

Fig. **90**, together with the following calculations, illustrates the above rules:

$$\text{Diameter of driven pulley} = \frac{36 \times 150}{270} = 20 \text{ in.}$$

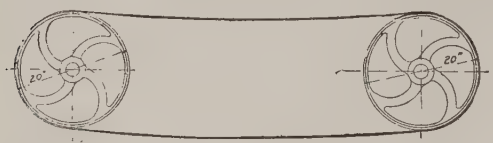
$$\text{Speed of driven shaft} = \frac{36 \times 150}{20} = 270 \text{ r.p.m.}$$

$$\text{Diameter of driving pulley} = \frac{20 \times 270}{150} = 36 \text{ in.}$$

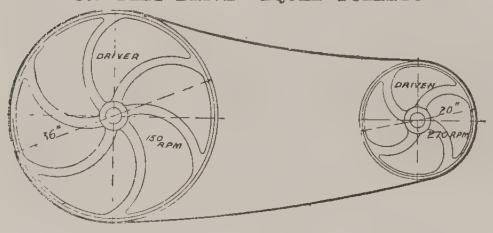
The thickness of the belt affects the calculations to a slight extent, because the true belt-speed should be measured on the centre line of the belt; when a belt bends round a pulley its inner surface is compressed and its outer surface is extended, but the centre line remains unaltered, and is consequently the theoretical driving line. The difference is not very appreciable with single belts and medium velocity ratios, but in speeding up from a slow-running shaft to a high-speed fan or dynamo, it may upset the calculation to the extent of 3 per cent., or even 5 per cent.

Speed Cones. When it is desired to drive a machine at various speeds from a shaft running at a constant speed, it is usual to employ speed cones as illustrated in **91**; they are arranged opposite each other, so that the smallest pulley of one set is abreast of the largest one of the other set; the added diameters of any two pulleys abreast of each other is a constant; that is, $A+C'=B+B'=C+A'$; the driving belt can then be readily slipped from one set to another, and the speed of the driven set altered accordingly. Assuming the shaft D to be the driver, and to be running at 150 revolutions per minute, then when the belt is on A and C′ as shown [**91**], the speed of shaft E is $\frac{150 \times 6}{12} = 75$ r.p.m.; when the belt is on B and B′ the speed of shaft E is $\frac{150 \times 9}{9} = 150$ r.p.m.; when the belt is on C and A′ the speed of E is $\frac{150 \times 12}{6} = 300$ r.p.m. The section of the cones is shown dotted; there are no arms except when the large cone is of a considerable diameter, or when there are a great number of steps; a boss and arms are then arranged to support it, as shown in **75**.

Open and Crossed Belts. Open and crossed belts are used on planing machines, screw-



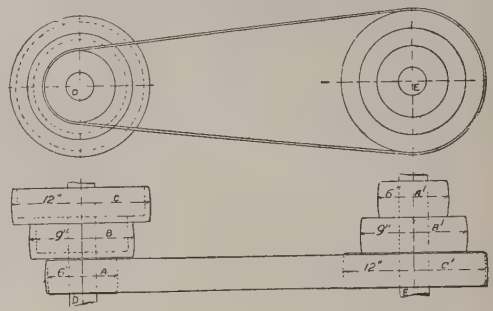
89. BELT DRIVE—EQUAL PULLEYS



90. BELT DRIVE—UNEQUAL PULLEYS

cutting lathes, etc., for the purpose of reversing the motion of a shaft after a certain operation has terminated. A typical example occurs in **92**, where A is the driving-pulley, B, C, and D are driven pulleys, B and D being keyed on their shaft and C running loose; the "open" belt is marked E and the "crossed" belt is marked F. Suitable striking gear is arranged to move both belts sideways at the same moment; when the belts are in the position shown [**92**], the open belt is driving the pulley B in the direction of the arrow G, whilst the crossed belt is driving the loose pulley only; upon striking the belts the open one drives the loose pulley and the crossed one pulley D, but in a reverse direction.

Rope Driving. Cotton and hemp ropes are used for the transmission of power in a similar manner to belts, but usually for main drives only. The textile mills of Lancashire afford numerous examples of direct rope-driving from main engine shafts to line shafts on the various floors, the fly-wheel itself doing duty as the driving pulley. Ropes are made by twisting three "strands" together in a right-hand direction; each strand is formed of "yarns" twisted together in a left-hand direction, the yarns themselves being spun from cotton or hemp fibres in a right-hand direction. The diameter of the finished rope varies from $\frac{3}{4}$ in. to 2 in.; the sizes in most frequent use are $1\frac{1}{4}$ in. to $1\frac{3}{4}$ in. diameter. The ultimate or breaking strength of a rope ranges between 7000 lb. and 11,000 lb. per

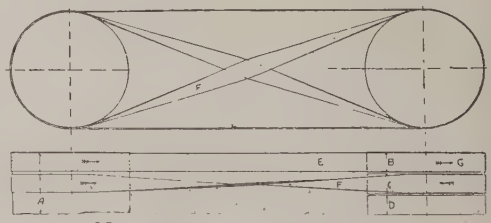


91. SPEED CONES

square inch. The safe working load is, however, only taken at 140 lb. per square inch, or, say, $\frac{1}{10}$ of the average breaking load; and unless this large factor of safety be allowed, the life of the rope is short. A main driving rope should last from five to eight years. The stress of 140 lb. per square inch does not represent the actual stress upon the fibres of the rope, but only that on the driving side due to the power transmitted. In addition to this, the rope has to sustain forces due to the wedging of the rope in the grooves of the pulleys, and also the stress due to centrifugal action. This latter stress increases as the square of the speed of the rope—that is, if the speed be doubled, the tension on the rope due to centrifugal force is increased four times, and if trebled is increased nine times; a speed is soon reached beyond which it is not economical to go, because the strength of the rope would be wasted in overcoming this force, instead of transmitting power. The highest economical speed lies between 4000 ft. and 5000 ft. per minute, and at this speed the effective load on the rope is about 200 lb. per square inch, instead of the 140 lb. per square inch due to the driving tension of the power which is transmitted.

Powers of Rope. At 4800 ft. per minute the powers which various ropes can transmit are as follows:

$\frac{3}{4}$ in. rope	= $8\frac{3}{4}$ h.p.	$1\frac{3}{8}$ in. rope	= 29 h.p.
$\frac{7}{8}$ " "	= $11\frac{3}{4}$ "	$1\frac{1}{2}$ " "	= $34\frac{3}{4}$ "
1 " "	= $15\frac{1}{2}$ "	$1\frac{5}{8}$ " "	= $40\frac{3}{4}$ "
$1\frac{1}{8}$ " "	= $19\frac{1}{2}$ "	$1\frac{3}{4}$ " "	= $47\frac{1}{4}$ "
$1\frac{1}{4}$ " "	= 24 "	2 " "	= $61\frac{3}{4}$ "



92. OPEN AND CROSSED BELT

These figures represent the maximum powers to be obtained from ropes at any speed whatever; further increase of speed does not result in an increased horse-power transmitted, but, on the contrary, it steadily declines, until at 8000 ft. per

minute the rope can barely withstand the centrifugal forces alone. Below 4800 ft. per minute the power transmitted, of course, decreases, but not in exact ratio of speed, because, as the speed becomes less, so the centrifugal forces decrease; at half the above speed—namely, 2400 ft. per minute—the following powers can be transmitted:

$\frac{3}{4}$ in. rope	= 6 h.p.	$1\frac{3}{8}$ in. rope	= 20 h.p.
$\frac{7}{8}$ " "	= 8 "	$1\frac{1}{2}$ " "	= 24 "
1 " "	= $10\frac{1}{2}$ "	$1\frac{5}{8}$ " "	= 28 "
$1\frac{1}{8}$ " "	= $13\frac{1}{2}$ "	$1\frac{3}{4}$ " "	= $32\frac{1}{2}$ "
$1\frac{1}{4}$ " "	= $16\frac{1}{2}$ "	2 " "	= $42\frac{1}{2}$ "

Since the capacity of a single rope is limited to a comparatively small horse-power, it is necessary to use a number of ropes on one pulley in order to transmit the required power, which may amount to several thousand horse-power in some cases. Small engines have from 3 to 10 ropes, larger ones 10 to 30, whilst some engines have been fitted with wheels having 50 and even 60 ropes.

Rope Wheels. The wheels are usually of cast iron and have machined grooves in the rim as shown in **72**, the proportions of which are given in the table. The diameter of a rope pulley should not be less than 30 times the diameter of the rope, otherwise the life of the rope is shortened by constant bending on too small a diameter. Rope pulley arms are usually oval in section, and may be calculated in the manner described for belt pulleys. Rope pulleys are, however, more carefully designed and manufactured, on account of their weight and of the higher speeds at which they run. Main driving pulleys on an engine frequently attain the enormous weight of 70 or 80 tons apiece. They are built up of a number of separate castings, the

ROPE GROOVES FOR PULLEYS

Diameter of Rope.	A	B	C	D	E	F	G
$\frac{3}{4}$ ..	$1\frac{5}{16}$	1	$1\frac{1}{8}$	$\frac{7}{16}$	$\frac{7}{32}$	$\frac{5}{16}$	$\frac{3}{8}$
$\frac{7}{8}$ ..	$1\frac{7}{16}$	$1\frac{1}{8}$	$1\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{16}$	$\frac{5}{16}$	$\frac{3}{8}$
1 ..	$1\frac{9}{16}$	$1\frac{1}{4}$	$1\frac{1}{2}$	$\frac{9}{16}$	$\frac{1}{8}$	$\frac{3}{8}$	$\frac{7}{16}$
$1\frac{1}{8}$ ..	$1\frac{3}{4}$	$1\frac{3}{8}$	$1\frac{5}{8}$	$\frac{9}{16}$	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{7}{16}$
$1\frac{1}{4}$ ..	$1\frac{15}{16}$	$1\frac{1}{2}$	$1\frac{7}{8}$	$\frac{5}{8}$	$\frac{13}{32}$	$\frac{3}{8}$	$\frac{1}{2}$
$1\frac{3}{8}$ ..	2	$1\frac{5}{8}$	2	$\frac{5}{8}$	$\frac{1}{2}$	$\frac{3}{8}$	$\frac{1}{2}$
$1\frac{1}{2}$ ..	$2\frac{3}{16}$	$1\frac{13}{16}$	$2\frac{1}{8}$	$\frac{3}{4}$	$\frac{9}{16}$	$\frac{3}{8}$	$\frac{1}{2}$
$1\frac{5}{8}$ ..	$2\frac{5}{16}$	$1\frac{15}{16}$	$2\frac{3}{8}$	$\frac{13}{16}$	$\frac{5}{8}$	$\frac{3}{8}$	$\frac{1}{2}$
$1\frac{3}{4}$ ..	$2\frac{1}{2}$	$2\frac{1}{16}$	$2\frac{1}{2}$	$\frac{7}{8}$	$\frac{11}{16}$	$\frac{7}{16}$	$\frac{5}{8}$
$1\frac{7}{8}$ ..	$2\frac{5}{8}$	$2\frac{3}{16}$	$2\frac{5}{8}$	$\frac{7}{8}$	$\frac{11}{16}$	$\frac{7}{16}$	$\frac{5}{8}$
2 ..	$2\frac{3}{4}$	$2\frac{5}{16}$	$2\frac{7}{8}$	1	$\frac{3}{4}$	$\frac{7}{16}$	$\frac{5}{8}$

boss is in two parts, machined and bolted together, the arms are separate and are cast hollow, cottared into the boss and bolted to the rim; the rim is in segments, faced up and bolted or cottared together. Such pulleys are made from 20 ft. to 34 ft. diameter; smaller ones down to 12 ft. diameter are made in halves, but the rims are frequently built up in segments; from 12 ft. to 8 ft. diameter they are simply made in halves, whilst 8 ft. pulleys are cast in one piece. The object in building up the larger sizes is to ensure a wheel free from initial stress due to contraction; the stresses arising from centrifugal action alone when such heavy masses are moving at a high speed are very considerable, and, in fact, it is not wise or safe to exceed 5000 ft. per minute with a cast-iron rim. Heavy wheel rims have been known to burst at 4500 ft. per minute. As the design of rope-driving pulleys is closely allied to flywheel design, it is more fully discussed under that heading in a later chapter.

Arrangements of Ropes. There are two methods of arranging the ropes for a given drive. The usual plan adopted in England and on the Continent is to use a separate rope for each groove in the pulley, the ropes being spliced to as nearly the same length as possible. In America a different arrangement is extensively employed; a single rope is wound continuously in a spiral round the pulleys, and is made to pass over a weighted pulley, which gives a certain tension to the ropes; by such means it is ensured that each rope element is taking its share of the drive. A great disadvantage of this method is that if the rope breaks the whole drive is at a standstill, and in all probability the rope becomes so entangled that a serious loss of time occurs before it can be got clear and a new rope reeved on.

Wherever possible, the driving side of the rope should occur underneath; then the sag of the slack or top side increases the arc of contact, and so adds to the efficiency of the drive. The length of a rope drive—that is, the distance from centre to centre of the pulleys—should be as great as possible—from 20 ft. up to 80 ft. or 100 ft.; it is best to arrange it horizontally, or at most at an angle of 45 degrees. The sag of a rope follows a curve termed a "catenary," which approximates a parabola, and this latter curve may be used when drawing out a rope drive to determine clearances. Single-rope drives are used occasionally for special machinery and for overhead travellers; the ropes are then small in diameter, in order to keep the pulleys down to a convenient size.

Toothed Gears. We have seen that a belt or a rope does not transmit power accurately, but that a certain loss of speed occurs, due to "slip." Toothed gears are not open to this objection, and are accordingly employed where motion has to be transmitted accurately. Another advantage accrues from their use, and that is that they are much more economical of space than belts or ropes. The simplest form of toothed gear is shown in **82**, and is termed *spur gear* or *spur and pinion*. The larger of the two wheels is the spur wheel and the smaller one is the pinion. The term *pinion* is applied somewhat loosely in practice, but is generally understood to mean the smaller of any two wheels in contact, or any wheel having less than twenty teeth.

The dotted circles marked A are the *pitch lines* or *pitch circles;* these are the theoretical lines of contact, and from them measurements are taken. The pitch of the teeth, B, is the distance from the centre of one tooth to the centre of the next one. When measuring a wheel it is convenient to take the pitch from the edges of the teeth, as B^1. That portion of the tooth, C, which extends above the pitch line is termed the *face* or *addendum;* while that portion, D, which lies below the pitch line is called the *flank* or *dedendum*. The extreme outer end, E, of the tooth is the *point*, and the lower end, F, is the *root*.

Forms of Teeth. The forms of the teeth of gear-wheels have occupied the attention of engineers to a very considerable extent; an ideal gear would have a constant motion identical with that of two smooth-faced pulleys whose diameter would represent the pitch circles in contact. If the tooth form does not permit this constant velocity at the pitch line, then a more or less noisy and inefficient gear results. A badly formed tooth is contributory to what is called *backlash*. A variation in velocity causes relative movement between the

teeth in gear, and they leave their driving faces and come into collision with the teeth in front of them, the amount of the backlash being equal to the clearance between the teeth.

There are two forms of teeth generally adopted—namely, *double curve* or *cycloidal*, and *single curve* or *involute*. The double curve tooth is shown in **76**, and the single curve tooth in **77**.

A method of striking out the double curve tooth is indicated in **81**. AB is the pitch circle, whose centre is at C. Upon it roll two circles, D and E, termed *generating circles*. The outer one, D, describes the outer or *epicycloid* curve; the inner one, E, describes the inner or *hypocycloid* curve. The diameter of each circle may be taken at twice the pitch. Taking the outer circle first, mark it out in a number of equidistant positions as shown, and draw the centre lines through to C; then take the arcs F G, F H, F I, F J, F K, and F L, and step round similar arcs on the generating circle in its various positions so that G M is equal to G F, H N is equal to H F, I O is equal to I F, J P is equal to J F, K Q is equal to K F, and L R is equal to L F, remembering always that the curved line or arc must be measured, and not a straight line or chord. Through the points M, N, O, P, Q, and R lies the true path of the *epicycloid* curve. The *hypocycloid* is obtained in a similar manner, with the inner generating circle rolling in the reverse direction. Only a portion of the curve is required for a tooth, as shown in hatched lines. The diameter of the generating circle has great influence on the thickness of the tooth at the root and at the point; if it were made of equal diameter to the radius of the pitch circle the flanks of the teeth would be radial straight lines. Now, the same generating circle which is used for a wheel must also be used for any wheel or pinion which has to gear with it; therefore the diameter of a generating circle is limited to the radius of the smallest pinion of any set of wheels gearing together, otherwise the teeth would be less in thickness at the root than at the pitch line, and the strength of the pinion would be reduced. The recognised limit for the lowest number of teeth in a pinion is 12, but 11, 10, and even 9 teeth are not uncommon on cranes and winches. Taking, however, 12 teeth as the minimum in average practice, the diameter of the generating circle works out to practically twice the pitch.

The Odontograph. The odontograph is an instrument invented to avoid the labour of marking out the cycloidal curves for each and every size of wheel and pinion that may be required. Suitable radii are given upon the instrument for the faces and flanks of teeth for all ordinary numbers. One of its edges is cut to an angle of 75°, which can be laid in certain definite positions relatively to the pitch and pitch line, and so used in order to obtain the centres of the radii.

The depth of wheel teeth is quite independent of the tooth curves; and it may be noted here that there is at present a distinct tendency to use shorter teeth than formerly; this tendency takes effect in machine-cut gears (which are described later), and would undoubtedly obtain in ordinary cast gear but for the confusion that would arise in many engineers' shops through interference with existing practice. Cycloidal and involute curves are theoretical lines, and do not vary, but tooth proportions are arbitrary, and are determined by trial and error in actual practice. For instance, in **81** it will be seen that the length of the tooth can be varied without affecting its true curve; naturally, a short tooth will carry a greater load than a long one in an inverse proportion to its length; the tooth itself is no stronger, but the length of the cantilever is less. Working conditions demand teeth of sufficient length to ensure good contact even when wheels are not set accurately and the pitch circles do not coincide. In dealing with gears to transmit great power, it is usual to design the teeth specially, and then the length of the tooth may be reduced to ·5 of the pitch, or even less.

Single-curve Teeth. The method of constructing the involute curve of a *single-curve tooth* is shown in **93**, where A B is the pitch line. First mark off the equidistant points D E F G H, and from each point draw a tangent to the curve; then set off the distance D I equal to the arc D C, E J equal to E C, F K equal to F C, G L equal to G C, H M equal to H C, and a curve drawn through the points I J K L M will be the involute required. It is, in effect, a curve formed by the unwinding of a cord from the arc of the circle.

An approximation sufficiently correct for practical purposes is to strike the curve with a radius equal to one-fourth of the radius of the pitch circle. Fig. **94** shows how this is arranged. A semicircle, A, is drawn on the radius of the pitch circle, and the centre, B, is located upon it; a dotted circle is drawn through the point as a *base circle* for striking the curves of the other teeth. This construction has, however, to be slightly modified when dealing with wheels having less than 30 teeth. The flanks have then to be made parallel with each other for certain distances, the amount of which is arbitrary, and depends upon the number of teeth.

Double-curve Teeth. The relative advantages of single and double curve teeth is a very much discussed question, and one which is by no means settled. The practice in England has been for many years distinctly in favour of double-curve teeth, due, no doubt, to the wide adoption of the odontograph instrument, together with an exaggerated idea of the theory that single-curve teeth cause undue pressure upon the shaft bearings. The tendency at present is to adopt the single curve universally, and this has been brought about largely by the introduction of *machine-cut* gears.

When toothed gears of a very fine pitch are required, it has been the practice to cut the tooth spaces from a solid rim, in order to attain sufficient accuracy to ensure quiet running. It has been left to Messrs. Brown & Sharpe, of America, to develop this idea, and to standardise the forms and proportions of machine-cut gears of all sizes and pitches. The Brown & Sharpe involute gear cutters are now used regularly all over the world, and are as much recognised as a standard article as the Whitworth and the Sellers screw threads are in their sphere. Gears having cast teeth are, of course, still widely used, but for all accurate and high-speed work cut gear has the monopoly.

Diametral Pitch. The base of calculation for cut gears is the *diametral pitch*. When drawing wheel teeth on paper, or when constructing a pattern, it is convenient and natural to measure the pitch of the teeth on the circumference of the pitch circle, and such a measurement it termed *circular pitch*. Now, when dealing with cut gears, this method of measurement disappears. The pattern-maker is not concerned with the spacing of the teeth—he simply has to prepare a wheel blank of a certain *diameter*; the machinist has to turn the blank casting to the correct *diameter*, and the gear-cutting machine is set to cut a certain number of teeth.

Consequently, circumferential measurements by rule or compass are not required in the process of manufacture. Therefore, the pitch is spoken of in terms of the diameter instead of the circumference of the wheel.

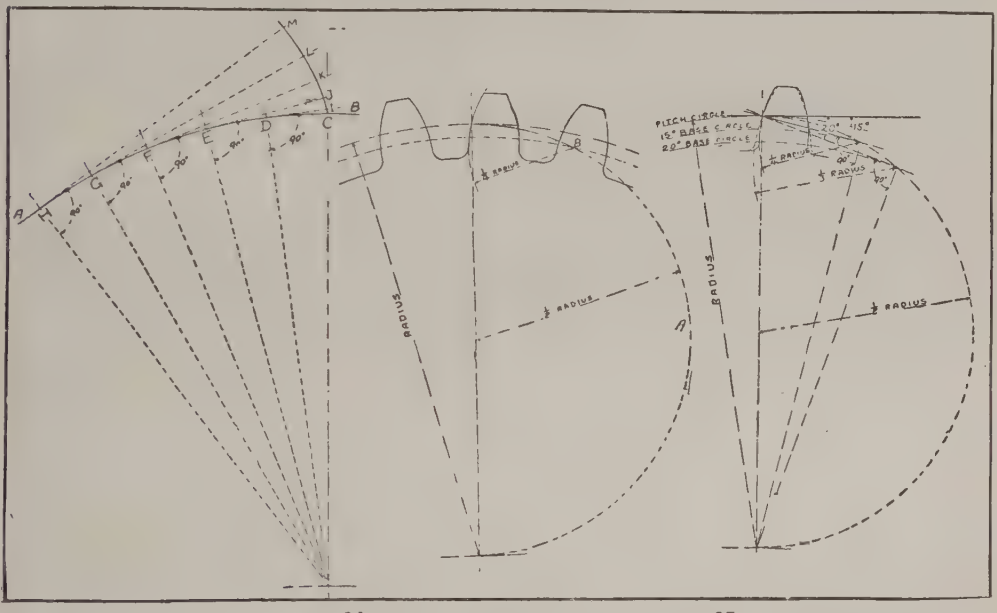
If the circumference of a pitch circle be divided by the number of teeth in the wheel, the result will be "circular pitch." In the same manner, if the diameter of the pitch circle be divided by the number of teeth, the result will be "diameter pitch." The *diametral pitch* is the reciprocal of diameter pitch. The *reciprocal* of a number is 1 divided by that number. Thus, the reciprocal of 4 is $\frac{1}{4}$, because $\frac{1}{4}$ will divide into 1 four times. Now, if we take a wheel having 48 teeth and a pitch diameter of 12 in., the diameter pitch is $\frac{12}{48} = \frac{1}{4}$ in., and the diametral pitch is $1 \div \frac{1}{4}$ in. $= 4$. In other words, diametral pitch is the number of teeth per inch of diameter of pitch circle; this idea may be a little

the number of teeth, and divide by the wheel diameter (convert to decimals):

$$\frac{60+2}{20{\cdot}66} = 3 \text{ diametral pitch.}$$

Relation of Diametral Pitch to Circular Pitch. The relation of diametral to circular pitch is the relation of the diameter of a circle to its circumference, which equals 3·1416. To obtain the equivalent circular pitch from a diametral pitch, divide the latter into 3·1416. Example: Required the equivalent circular pitch to 5 diametral pitch: $\frac{3{\cdot}1416}{5} = {\cdot}6283$ circular pitch. Conversely, required the equivalent diametral pitch to $1\frac{1}{2}$ in. circular pitch: $\frac{3{\cdot}1416}{1{\cdot}5} = 2{\cdot}0944$ diametral pitch.

A table is given on the next page showing the equivalent circular pitches for diametral pitches from 1 to 50. The Brown & Sharpe involute teeth



93. INVOLUTE CURVE **94.** MARKING OUT AN INVOLUTE TOOTH **95.** ANGLE OF OBLIQUITY

difficult to grasp at first, but the following calculations will show the simplicity of its application:

To find the pitch diameter of a wheel having, say, 94 teeth of 3 diametral pitch: Divide the number of teeth by the diametral pitch:

$$\frac{94}{3} = 31{\cdot}33 \text{ in.} = 31\tfrac{1}{3}\tfrac{1}{2} \text{ in. pitch diameter.}$$

To find the diameter of a wheel blank to cut, say, 94 teeth of 3 diametral pitch: Add 2 to the number of teeth and divide by the diametral pitch: $\frac{94+2}{3} = 32$ in. diameter of blank, or *whole diameter of wheel*, as it is sometimes termed.

To find the diametral pitch of a wheel having, say, 60 teeth, and of 24 in. diameter: Divide the number of teeth by the diameter of the pitch circle: $\frac{60}{24} = 2\frac{1}{2}$ diametral pitch.

To find the diametral pitch of a wheel, say, $20\frac{2}{3}\frac{1}{2}$ in. whole diameter, and having 60 teeth: Add 2 to

may be set out generally as described for **94**, the proportions being as follows:

Height of tooth from pitch line, ·3183 circular pitch. Width of tooth on pitch line, ·5 circular pitch. Depth of tooth below pitch line, ·3683 circular pitch.

Tooth Proportions. The following gives the standard proportions, although the practice in recent years has been to shorten the teeth.

CIRCULAR PITCHES. Having the numbers of teeth given, to find distance between centres: Multiply half the sum of the teeth by the circular pitch, and divide by 3·1416.

To find pitch diameter: Multiply the number of teeth by the circular pitch, and divide by 3·1416. Or multiply by 0·3183.

To find the number of teeth: Multiply the pitch diameter by 3·1416, and divide by the circular pitch.

To find outside diameter: The number of teeth

No. of Teeth	Factor for Strength, Y. Involute 20 deg. Obliquity	Involute 15 deg. and Cycloidal	Radial Flanks	No. of Teeth	Factor for Strength, Y. Involute 20 deg. Obliquity	Involute 15 deg. and Cycloidal	Radial Flanks
12	·078	·067	·052	27	·111	·100	·064
13	·083	·070	·053	30	·114	·102	·065
14	·088	·072	·054	34	·118	·104	·066
15	·092	·075	·055	38	·122	·107	·067
16	·094	·077	·056	43	·126	·110	·068
17	·096	·080	·057	50	·130	·112	·069
18	·098	·083	·058	60	·134	·114	·070
19	·100	·087	·059	75	·138	·116	·071
20	·102	·090	·060	100	·142	·118	·072
21	·104	·092	·061	150	·146	·120	·073
23	·106	·094	·062	300	·150	·122	·074
25	·108	·097	·063	rack	·154	·124	·075

plus 2 is multiplied by the circular pitch, and divided by 3·1416; or multiplied by 0·3183.

To find thickness of tooth at the pitch line: Divide the pitch by 2.

To find the whole depth of tooth: Multiply the circular pitch by 0·6866.

To obtain the working depth of tooth: Multiply the circular pitch by 0·6366.

To obtain the bottom clearance: Multiply the circular pitch by 0·05.

Diametral Pitches. Having the number of teeth given, to find distance between centres: Divide half the sum of the teeth of both gears by the diametral pitch.

To find pitch diameter: Divide the number of teeth by the diametral pitch.

To find the number of teeth: Multiply the pitch diameter by the pitch.

To find outside diameter: Add 2 to the number of teeth, and divide by the pitch.

To find thickness of tooth at the pitch line: Divide 1·5708 by the diametral pitch.

To find the whole depth of tooth: Divide 2·157 by the diametral pitch.

To obtain bottom clearance: Divide 0·157 by the diametral pitch.

Strength of Spur Teeth. The strength of spur-wheel teeth may be calculated upon two bases: the one by considering a static load to be sustained by the tooth, and the other by considering the horse-power to be transmitted. For slow-moving machinery, it is convenient to estimate the load which comes on the wheel teeth, and to assume that this load is applied at the point of one tooth; the case is then treated as a simple cantilever loaded at the outer end. If the teeth are badly made, or if the wheels are not properly adjusted on the shafts, the load may come on one corner of the tooth instead of being distributed evenly across the face. Many formulæ in use deliberately assume such to be the case in ordinary work, but with modern machine-moulded or machine-cut gears there is no necessity to make such provision. The number of teeth in gear at the same moment will make a difference to the carrying capacity of a wheel; with large wheels of fine pitch gearing together, several teeth will divide the load between them; but if a small pinion be geared with a wheel, the full load may easily come on one tooth only.

Properly speaking, each individual case should be investigated and designed accordingly. Having determined the load which the tooth must carry, multiply that load by the full depth of the tooth for a bending moment; the modulus of a rectangle is $\frac{B H^2}{6}$ where B is the breadth or face of the tooth, and H is the thickness at the root; multiplying the modulus by the safe stress per square inch gives the moment of resistance of the tooth, which should be equal and opposite to the bending moment. A safe stress for cast iron is 3000 lb. per square in., and 10,000 lb. per square in. for cast steel. [See the table given below.]

The thickness at the root of an odontograph tooth varies from ·4 to ·6 of the circular pitch when ranging from 15 to 60 teeth. The breadth or face of a toothed wheel may vary from one and a half to three times the circular pitch.

There are 40 to 50 different rules in existence for the calculation of the horse-power which may be transmitted by toothed gearing, the majority of them depending upon an arbitrary factor which covers allowances for inaccurate workmanship and stresses due to centrifugal action. A safe rule is $HP = \frac{D P F N}{1000}$, where D = pitch diameter of wheel in inches, P = circular pitch, F = face of wheel in inches, N = speed of wheel in revolutions per minute.

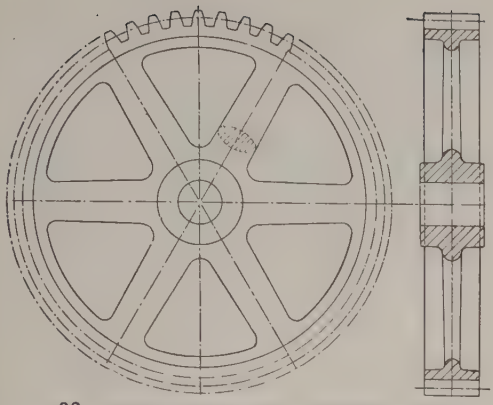
TABLE OF DIAMETRAL AND CIRCULAR PITCHES

Diametral Pitch	Circular Pitch	Diametral Pitch	Circular Pitch
1	3·1416	15	·2094
1¼	2·5133	16	·1963
1½	2·0944	17	·1848
1¾	1·7952	18	·1745
2	1·5708	19	·1653
2¼	1·3963	20	·1571
2½	1·2566	22	·1428
2¾	1·1424	24	·1309
3	1·0472	26	·1208
3½	·8976	28	·1122
4	·7854	30	·1047
5	·6283	32	·0982
6	·5236	34	·0924
7	·4488	36	·0873
8	·3927	38	·0827
9	·3491	40	·0785
10	·3142	42	·0748
11	·2856	44	·0714
12	·2618	46	·0683
13	·2417	48	·0654
14	·2244	50	·0628

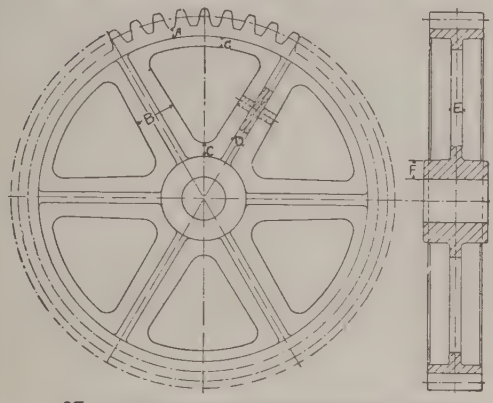
The Wilfred Lewis Formula. This is used largely in connection with machine-cut gear. It was introduced by Mr. Wilfred Lewis at Philadelphia, U.S.A., in 1893. He assumes that the whole load is taken upon one tooth, and that the tooth is a cantilever loaded at one end. From a consideration of various sizes of involute and cycloidal gears he selects the weakest cross-section of each, and determines its relation to the pitch; then from these data deduces the formula W = S P F Y, where W is the load transmitted in pounds, S is the safe working stress per square

SAFE WORKING STRESSES FOR DIFFERENT SPEEDS

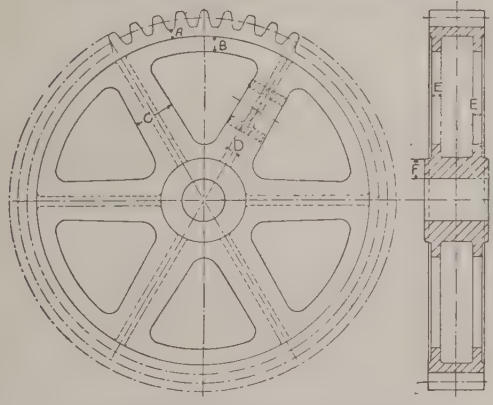
Speed of Teeth in feet per Minute.	100 or Less	200	300	600	900	1,200	1,800	2,400
Cast iron	8,000	6,000	4,800	4,000	3,000	2,400	2,000	1,700
Steel ..	20,000	15,000	12,000	10,000	7,500	6,000	5,000	4,300



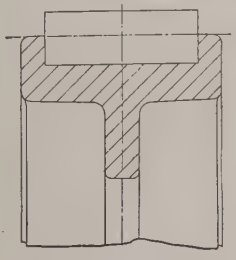
96. WHEEL WITH OVAL SECTION ARMS



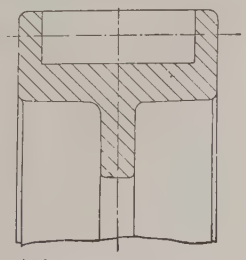
97. WHEEL WITH CROSS SECTION ARMS



98. WHEEL WITH H SECTION ARMS



99. HALF SHROUDED TOOTH



100. FULL SHROUDED TOOTH

inch in pounds, P is the circular pitch, F is the face of the tooth in inches, and Y is a factor varying with the shape and number of teeth. The values of Y and S are given in the table on page 5646.

It will be noticed in the table that the involute is given as 20° and 15° obliquity; the angle of obliquity is measured between a horizontal line cutting the pitch circles at their point of contact and a line drawn perpendicular to the curve of the tooth, and being a tangent to the base circle. Fig. **95** shows the effect on the thickness of the tooth due to an alteration in the angle of obliquity; the greater the angle, the stronger the tooth. A 20° obliquity gives a tooth radius of about one-third the pitch circle radius.

When drawing gears to be cut with Brown & Sharpe cutters the angle of 15° may be taken.

Arms of Spur Wheels. These are made oval section [**96**], cross section [**97**], or H section [**98**]. The first-mentioned is used for comparatively light machine-cut gears, the second is used chiefly for gear wheels moulded from patterns, the third is adopted for machine-moulded wheels and for large and heavy gears. Frequently machine-cut gears are made with solid web plates without arms. The strength of a wheel arm may be calculated in the same way that we dealt with pulley arms. For the cross arm section the following proportions give good results:

Thickness of rim (A) = ·46 circular pitch
Width of arm (B) = circular pitch × 2
Depth of rib (C) = circular pitch
Thickness of arm (D) = ·43 circular pitch
Thickness of arm (E) = ·5 circular pitch
Thickness of boss (F) = $\frac{1}{3}$ of shaft diameter + $\frac{1}{4}$ in.

The above dimensions apply at the centre of the arms, the taper being about $\frac{3}{4}$ in. per foot either way. The number of arms in a wheel may be taken as:

Up to 1 ft. 6 in. diameter .. .. .. 4 arms
Up to 8 ft. diameter .. .. 6 arms
Above 8 ft. diameter .. .. 8 arms

The proportions for H arms may be taken as follows:

Thickness of rim (A) = ·375 circular pitch
Depth of rib (B) = A + ·01 pitch diameter
Width of arm (C) = circular pitch + ·035 pitch diameter
Thickness of web (D) = ·375 circular pitch
Thickness of flange (E) = $\frac{1}{8}$ of breadth of tooth
Thickness of boss (F) = $\frac{1}{3}$ of shaft diameter + $\frac{1}{4}$ in.

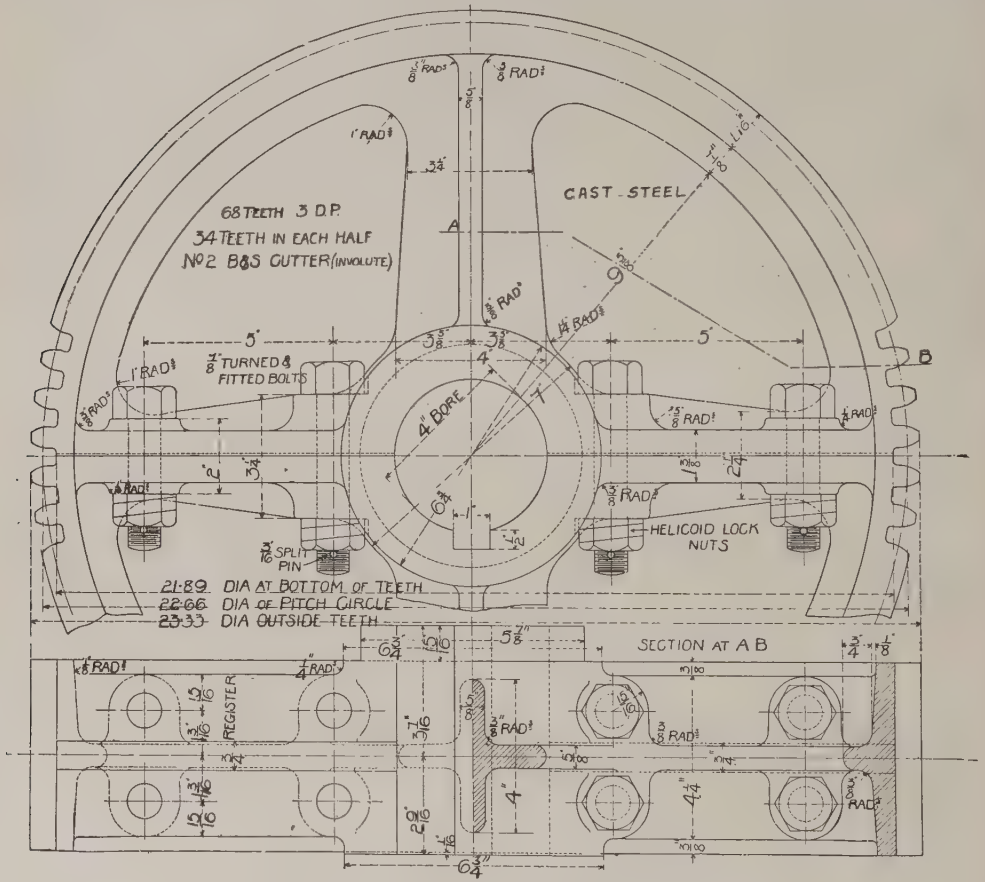
The remarks concerning the taper and the number of arms for the cross section arms apply equally to H arms. It will be noticed that in the cross and H section arms the face of the wheel is slightly wider than the width of the arms, this giving a better appearance to the wheel than if both were flush, and in the case of machine-cut gear it facilitates the machining of the sides.

Cast gears are frequently shrouded up to the pitch circle as **99**, full shrouded as **100**, or shrouded partially, or wholly on one side only; this adds from 20 to 50 per cent. to the strength of the gear. A common device is to shroud a pinion, but not the wheel it gears with, this being done to compensate for the unequal strength of the teeth at their roots. The thickness of the shroud may be one-third of the circular pitch.

Split Gears. Sometimes gear wheels are made in halves for convenience of renewal. A typical example is given in **101**, which represents a working drawing of a *split spur wheel* for an electric tramcar axle. It is necessary both for

railway and tramway rolling stock to force the running wheels upon the axles with sufficient pressure to ensure their rigidity when negotiating a curve at high speed, for if a wheel then slipped sideways upon its axle the vehicle would be instantly derailed. Now, when the wheels are so securely fastened to an axle, it is very important that anything between them shall be removable without disturbing them, and hence the dividing of the driving spur, which is keyed to the axle between the two running wheels.

Looking at the drawing **101**, it will be noticed that a groove is planed across the joint of one half to receive a register formed on the other half.



101. SPLIT GEAR WHEEL FOR ELECTRIC TRAMCAR AXLE

This relieves the bolts from shearing forces while the teeth are being cut, and also from side pressures should they occur when running. Note the section cut on A B joined by a diagonal line for the convenience of showing two sections not strictly in the same plane. In wheels of this nature it is necessary to see that they contain an even number of teeth, so as to divide properly without parting a tooth at the joint. There is no necessity to show all the teeth on the drawing. In the data given on the drawing for cutting the teeth, D P, of course, means diametral pitch, whilst the reference to No. 2 B. & S. cutter means a Brown & Sharpe involute cutter No. 2.

Large spur wheels are built up in a similar manner to that described for large rope wheels, and chiefly for the same reasons. Gear teeth are also formed upon the rims of flywheels.

Speeds of Wheels. The relative speeds of gear wheels may be calculated in the same way as in the case of belt pulleys by using the pitch circle diameters, except that there is no loss due to slip. We may, however, simplify the calculations by using the number of teeth contained in a wheel instead of its pitch diameter. This is useful when cut gears are involved, as their pitch diameters may run into vulgar fractions or decimals.

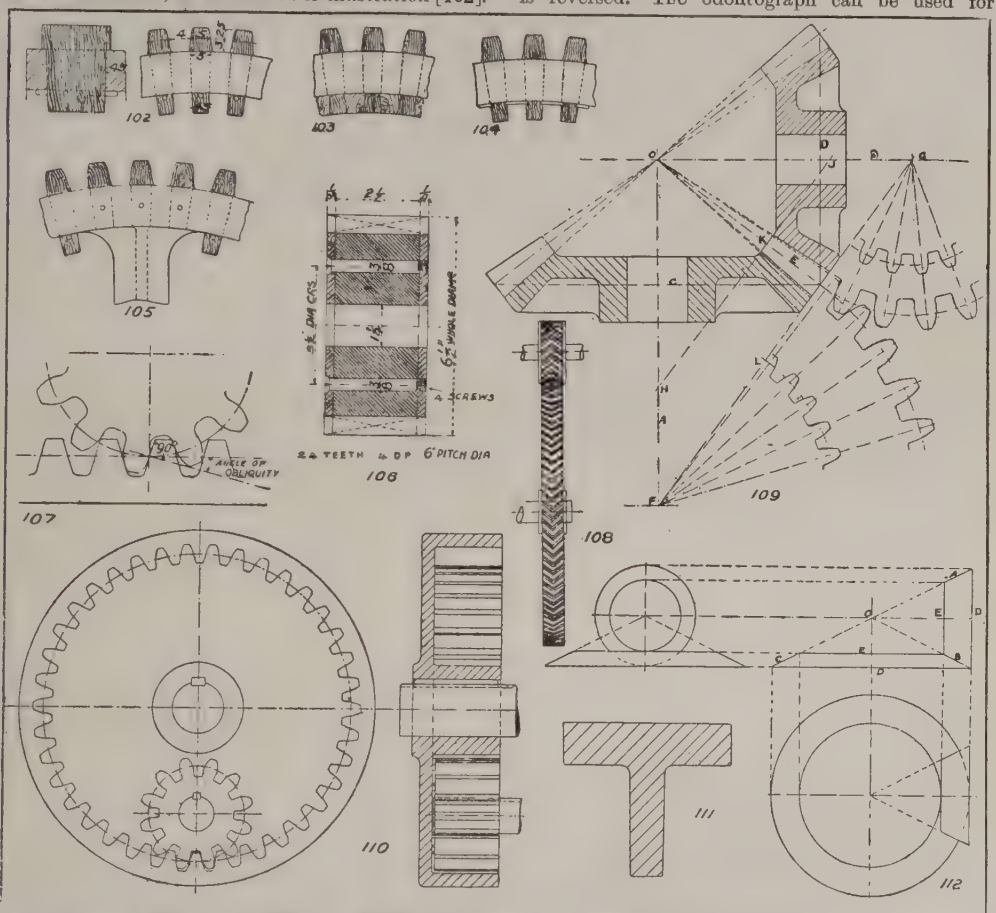
As in the case of rope wheels, there is a limiting speed beyond which gears should not be run. Cast-iron gears should not be run above 2000 ft. per minute at the pitch line; cast-steel gears, 2500 ft. per minute; small machine-cut gears, 3000 ft. per minute; above these speeds, gearing becomes noisy, and the wear is excessive.

Raw-hide Gears. Pinions which run at high speeds, such as those on electric motor spindles, are frequently made of raw hide. Discs of ox-hide are cemented together in layers under pressure in order to form the rough blank, which is then machined all over to finished sizes; side-plates—usually of gun-metal—are fitted as shown in section **106**, and the teeth are cut through the hide and through the metal plates. The object in using raw hide is to ensure noiseless running.

Mortise Teeth. Another and an older device to ensure a quiet running gear is to make the wheel teeth of wood; such teeth are termed *cogs;* are made separately by hand labour, and then fitted into slots cast in the wheel rim. Fig. **102** shows a good method of securing the teeth, as well as the proportions for tooth and wheel rim; the figures given are to be multiplied by the circular pitch in order to obtain the actual dimensions. Mortise wheels are used in flour-mills, cotton-mills, etc. The cogs are made of well-seasoned oak, acacia, hornbeam, or apple-tree, and the grain must run in a radial direction, as shown in the illustration [**102**].

necessary to make it right and left, or *double helical,* as it is termed, in order to avoid end-thrust on the shafts. These gears are frequently cast, but increasing numbers are being machine-cut. They are used for rolling-mill engines when reversal under load occurs. The usual angle for the teeth is 30 deg. measured from a horizontal line parallel with the shaft.

Internal Gears. These gears are made by forming the teeth upon the inside of the wheel rim, as indicated in **110**. The principle of tooth formation is the same as for outside teeth, but the spaces become the teeth —namely, the tooth curve is reversed. The odontograph can be used for



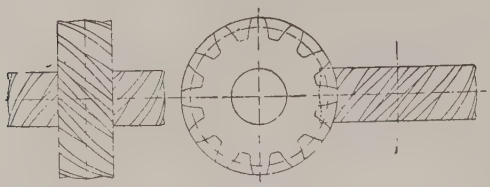
102–105. Mortise teeth (**102.** pinned; **103.** wedged; **104.** plated; **105.** pinned at arms); **106.** Raw-hide pinion; **107.** Rack and pinion; **108.** Helical toothed spur-gear; **109.** Bevel wheel and pinion; **110.** Internal spur-gear; **111.** Bevel wheel (arm section); **112.** Conical cylinders for bevels

Instead of holding the teeth by means of pins, wooden wedges, as **103**, or steel plates, as **107**, may be used: and pins are used where the arms occur, as in **105**. This class of gear is expensive, and is gradually falling into disfavour.

Helical Teeth. A quiet gear drive is obtained by making the teeth short lengths of a right and left hand screw or helix, as shown in **108**; the theory of construction is based upon an almost obsolete form of gear termed *stepped gear,* where the width of the teeth is divided into a number of equal parts, and each part is moved slightly in advance of its fellow. The merging of these steps into a straight line gives a helical curve to the tooth; it is

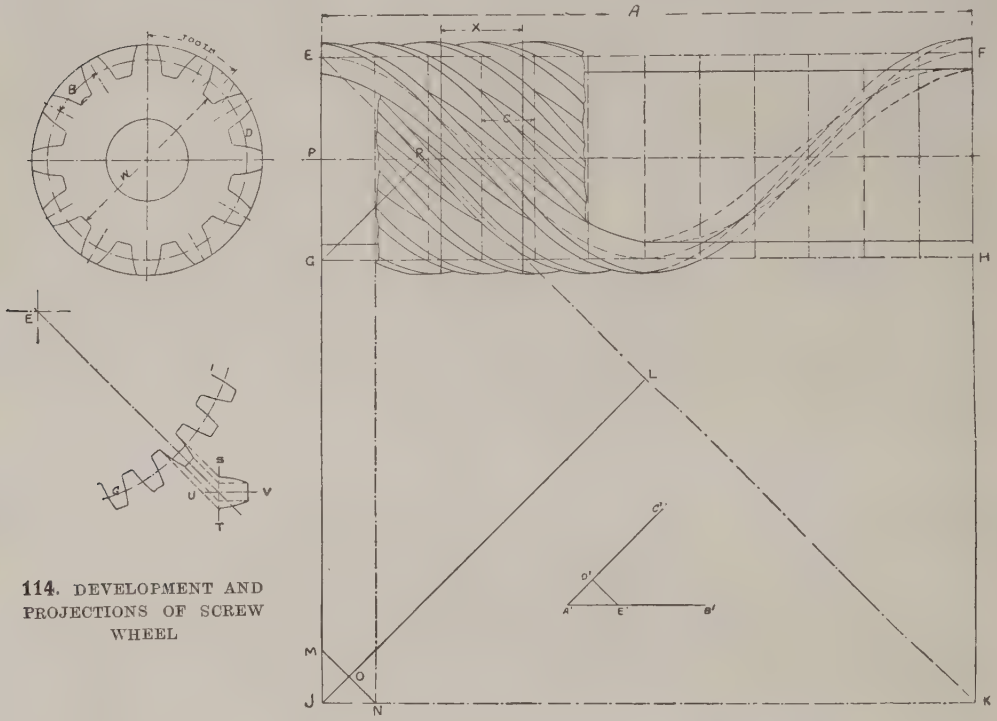
cycloidal teeth, but the face curve is marked from the flank data on the instrument, while the flank curve is marked from the face data. If involute teeth are struck, then the curve becomes concave instead of convex. When the ratio of wheel and pinion becomes very small, difficulties are encountered by reason of the teeth fouling each other. Normally, there should be at least a difference of 15 teeth between wheel and pinion. Internal gears are used on lathe headstocks, revolving gears on cranes, and so forth, or in cases in which both driving and driven shaft must rotate in the same direction.

Rack. A rack is a straight line of teeth, as **107**. It is used to produce rectilinear motion from



113. SCREW GEARS

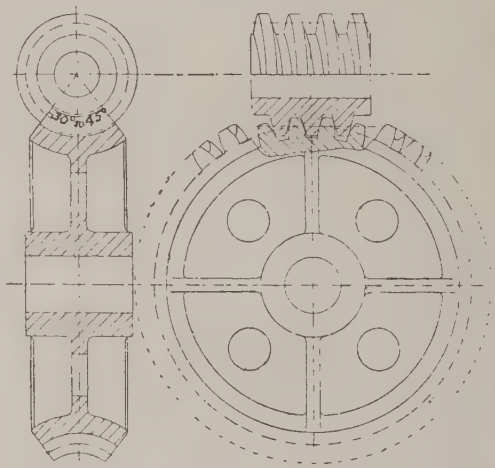
together, their axis being at right angles. The screw threads on both wheels are of the same hand; the number of teeth is counted as the number of screw threads involved, in the same way as we would speak of a double, triple, or quadruple thread screw. In the case illustrated there are 12 threads, or teeth, in each wheel; they will therefore transmit motion at equal velocities. But such gears can be made with different diameters and numbers of teeth, in order to give different velocities. The method of



114. DEVELOPMENT AND PROJECTIONS OF SCREW WHEEL

rotary motion, or vice versa; it is applied to tables of planing machines, the operation of sluice-doors, and so forth. The teeth may be marked out with the odontograph for cycloidal curves. If a rack is required to gear with an involute pinion, then the face and flank become a straight line drawn at right angles to the angle of obliquity, as in **107**. A rack is, in effect, part of a circle of infinite diameter; the circumference of a circle approaches a straight line as the diameter increases, and when the diameter is infinite any part of the circumference is a straight line. Cycloidal curves are formed by the rolling of generating circles upon a straight line, as well as upon a curved line, but an involute struck from a straight line is a straight line.

Screw Gears. When the axes of wheels gearing together are not in the same plane, recourse is had to *screw* or *spiral* gears. The teeth are formed upon cylindrical surfaces, but they are not parallel with the axes of the cylinders; each tooth is a portion of a spiral thread or helix. A screw wheel may have any number of such teeth from one upwards; a one-toothed screw wheel is termed a *worm*, and corresponds to a single-thread screw; a many-toothed wheel corresponds to a multiple-thread screw. The section of these screw threads is a standard tooth form, generally the involute. Fig. **113** shows a pair of screw wheels gearing

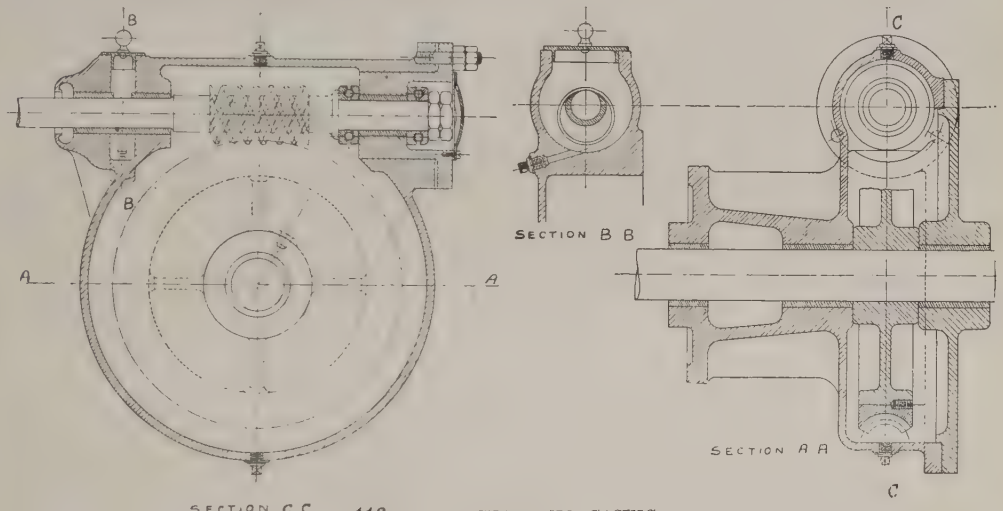


115. WORM AND WORM WHEEL

drawing a screw wheel is shown in **114**, together with explanatory projections. The *primary pitch* or *lead of spiral*, A, is the length of cylinder required to complete a turn of the screw or spiral; the *circular*

pitch, B, is the distance between the centres of adjacent teeth, measured around the circumference; the *normal pitch* is the distance between the centres of adjacent teeth, measured at right angles to the spiral; the *divided axial pitch*, C, is the distance between the centres of adjacent teeth measured on the axial line.

The normal pitch may be regarded as the true pitch of the teeth, as compared with the circular pitch of a spur wheel; for although it does not represent direct circumferential measurement, yet the standard tooth profiles and proportions are based thereon. Pitch diameters, spiral leads, and circular pitches may vary in any two wheels in gear, but the normal pitch must be constant, otherwise they will not work together. In order to set out a screw wheel, it is convenient to start with the circular pitch, and this is readily obtained from the normal pitch by means of the diagram in **114**. Draw a horizontal line, A′ B′, and extend a line, A′ C′, representing the tooth angle, and draw a line normal to this and of a length equal to the normal pitch, D′ E′; then A′ D′ equals the circular pitch. When the axes of the shafts intersect at right angles, as in **113**, it is essential that the sum of the respective tooth angles be 90 deg., and it is, of course, convenient to make each one 45 deg.



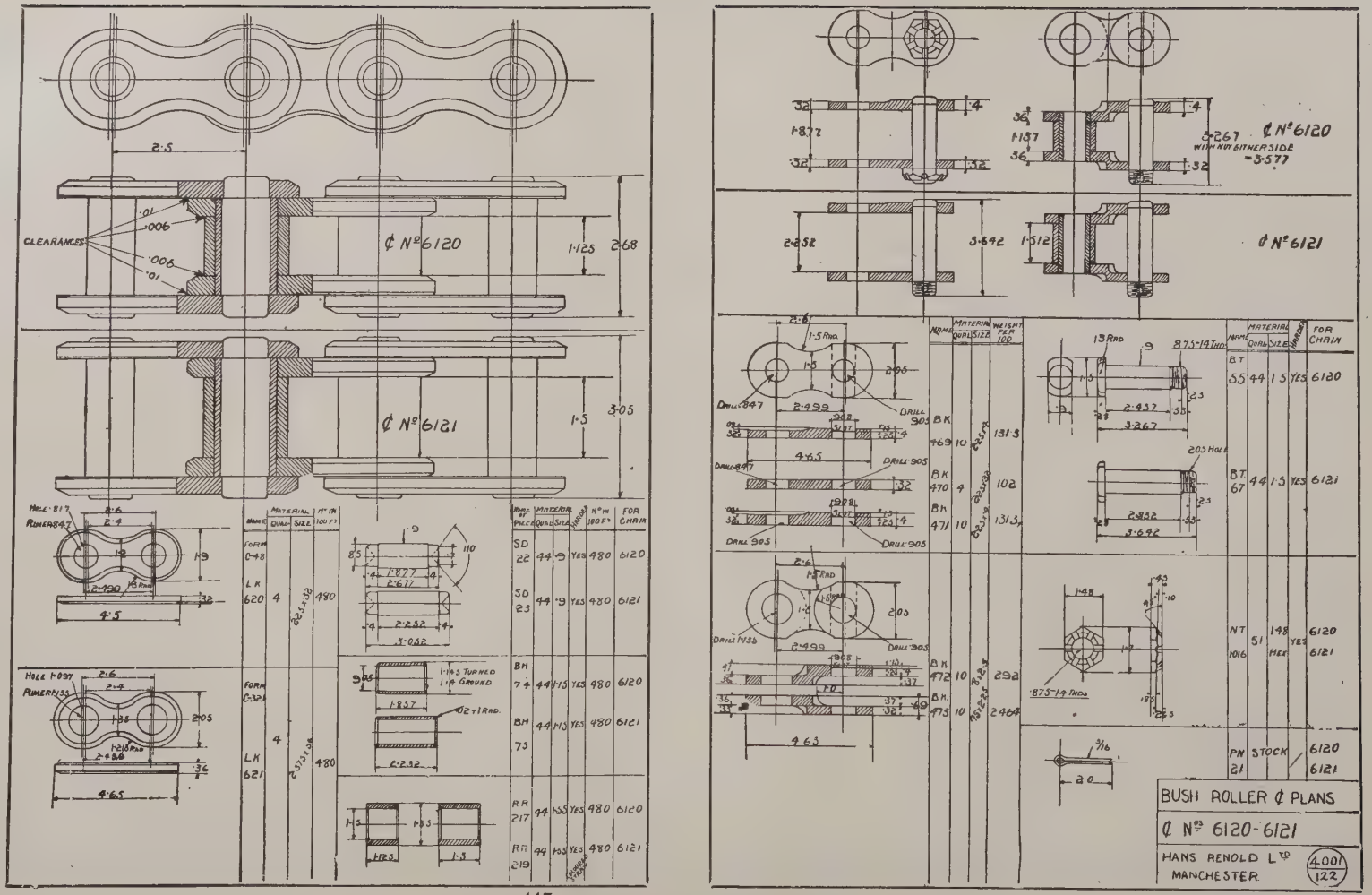
116. WORM GEAR AND CASING

Delineating the Spiral. Having obtained the circular pitch, calculate the pitch diameter, as in the case of spur gears, and draw the pitch circle, D, in face elevation [**114**], and also in side elevation, E F G H, which latter may be termed the *pitch cylinder*. Unroll this cylinder until the length, E J, represents its circumference, and then draw the diagonal, E K, which is the developed spiral, and lay down a line from J to L perpendicular to E K. Now divide E J into as many parts as there are teeth in the wheel. Taking one of these parts, J M, we have the circular pitch. Then divide J K into the same number of parts, and take one of them, J N; draw a line from N to M, cutting J L at O, and then J O is the normal pitch, and J N is the divided axial pitch. The next step is to develop the end elevation of the teeth in order to draw the face view. To do this it is first necessary to ascertain the diameter of the normal pitch circle, and this must be measured in the same plane as the normal pitch. Upon the line E J mark off a distance, E P, equal to the radius of the pitch cylinder, and draw a horizontal line, P R, cutting E K at R; then lay down a line, R G, perpendicular to E K, and E G is the radius of the normal pitch circle. To develop the teeth, transfer the radius, E G, to the lower left-hand view [**114**], and upon it mark out involute teeth of the pitch required, as in ordinary spur gears. Selecting a tooth whose centre line coincides with the angle of the spiral, we project its various thicknesses upon a vertical line, S T, and re-project them upon a horizontal line, U V, the depth of the tooth remaining the same in each case. We may now transfer the tooth developed on line U V to the face elevation of the wheel. The teeth and the spaces look abnormally wide, but this is, of course, due to the fact that they are not perpendicular to the face of the wheel.

The pitch line is now projected upon the cylinder in the same manner as we projected the helix and the screw head on page 5404. A tooth may be also projected in a similar way by considering it to be coiled on a cylinder of a diameter equal to that of the wheel measured under the teeth, as W. There is no necessity to draw the complete helix in actual practice, but it is shown so in **114**, in order to present the principle in as clear a manner as possible. Further teeth may be drawn without the labour of projecting each one. Make a tracing of one half helix, and move it successively one axial pitch, pricking off the tooth points in turn; the tooth curves may then be drawn through the points so obtained. A slice may be taken from the cylinder of projected spirals, as X, and this slice is the screw wheel required. The width, X, should be sufficient to ensure at least one pair of teeth being well in contact before the next pair leave contact. This is attained if the width be made to contain a pitch and a half measured circumferentially, as shown in the face elevation.

Screw gears may be made with their axes at various angles, and with wheels of various diameters; the teeth of helical gears, as mentioned earlier in this lesson, are portions of similar spirals.

The Worm and Wheel. This is a true screw gear, with axes usually, though not necessarily, at right angles [**115**]. The worm may be a single thread or multiple thread, the wheel containing many portions of internal threads, formed



117. BUSH ROLLER CHAIN DRAWING

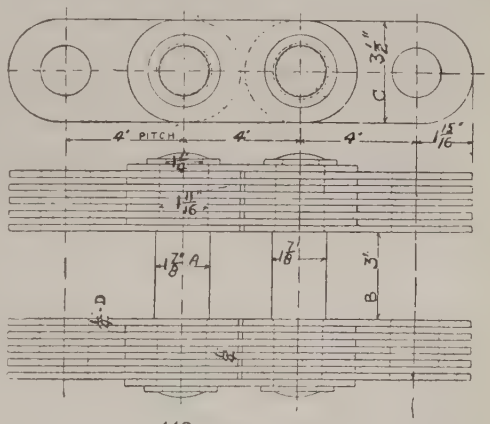
on an external surface. The sections of the threads are involute teeth, those of the worm having straight faces and flanks similar to a rack. The projection of the worm presents no difficulty, since it is a true spiral. The number of threads on the worm affects the speed of the worm wheel in direct ratio—that is to say, a single, double, or triple thread worm driving a wheel having, say, 33 teeth would have to make 33, 16½, and 11 revolutions respectively to each revolution of the wheel. Worm gears are generally used for the purpose of speed reduction on account of the great difference obtainable in a small space. Fig. **116** shows a typical example of a worm gear reduction in an oil-tight case. The worm wheel itself has a phosphor-bronze rim, in which the teeth are cut, this rim being fitted tightly on to a cast-iron centre, and secured thereon by means of four set-screws, spaced circumferentially. The worm is of mild steel, triple threaded, left hand; the wheel has 60 teeth. The worm shaft is coupled to an electric motor spindle running at 500 revolutions per minute, and the speed of the worm wheel shaft is therefore $\frac{500 \times 3}{60} = 25$ revolutions per minute. The casing is of cast iron, and has a circular bracket cast on as shown, in order to support it. This bracket may be arranged in any position desired to suit the application of the gear reduction—that is, it may be cast underneath or on one side if necessary. The casing forms an oil-bath for the gear to run in, and the worm should preferably be arranged underneath the wheel, so as to ensure plenty of oil getting at the working teeth. Ball bearings are fitted to the worm spindle to reduce the friction due to the end-thrust of the worm, these bearings being carried in a gland-shaped casting, which enables them to be removed bodily with the worm. It will be noticed that the worm is solid with the spindle, which is usual with small worms, as there would not be sufficient metal left under the threads if they were bored out for the reception of the spindle. A small oil-bath is also arranged for the worm spindle, and an oiling ring rests on the spindle and dips into the oil; this is the common device adopted to secure the proper lubrication of high-speed shafts in connection with motors and dynamos, and the like.

The diameter of a worm is generally from three to five times the circular pitch, and the angle of engagement, which determines the width of a worm wheel is usually 30° to 45°, as indicated in **115**.

Bevel Gears. We have hitherto only dealt with gears having their teeth formed upon parallel surfaces; bevel gears have their teeth formed upon conical surfaces, and are used for connecting shafts which are not parallel. Fig. **112** gives three views of a pair of conical cylinders in contact, having their axes at right angles and intersecting at O. Considering the lines of contact A, B, and C as pitch lines, ordinary cycloidal or involute teeth may be formed upon them; the pitch circle, the pitch, and the section of tooth are reduced from the "major" diameter, D, to the "minor" diameter, E, following radial lines to O. A section of a pair of bevels is given in **109**, together with the method of marking out the teeth at the major and minor diameters. Draw the axes or shaft centre lines, O A and O B, intersecting at O; then the major diameters, C and D; then the pitch lines extending to O; mark off the width of the tooth, E, and its depth and clearance; the major diameter is counted as the true pitch diameter, and the ordinary proportions of teeth, etc., apply there; the width of the tooth may be taken as the same as in spur gears. Lines are now drawn at right angles to the pitch lines of the teeth and extended to F and G and to H and J; arcs are then struck from F and G, the outer arc in each case being the developed pitch circle at the major diameter, and upon which the teeth are marked out as in spur gears, the inner arc being the developed pitch circle at the minor diameter. The radius of the inner arc for the bevel wheel is taken from H K, and is transferred to F L; radial lines are then drawn from the outer arc to centre, F, and upon these lines the pitch and the tooth section diminish regularly. The corresponding depth of tooth is taken by compasses from the minor diameter in the sectional view. The development of the teeth on the inner arc of the pinion is dealt with in the same manner as for the wheel.

When bevel gears are made with equal diameter wheels they are termed *mitre gears*, from the fact that the pitch lines make an angle of 45° with the axes of the shafts. Bevel gears may be made with axes at other than right angles; if the angle be greater than 90°, they are frequently termed *angle spur gears*.

The thickness of the rims of bevel gears is made about ·56 of the pitch at the major diameter, and

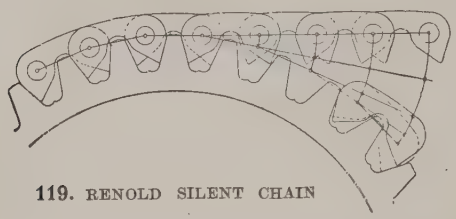


118. STUD CHAIN

decreases radially to the minor diameter. The arms are usually made T section, as in **111**, and to the proportions given for cross arms for spur wheels. The strength of a bevel tooth is calculated at the mean pitch. Bevel gears may be half shrouded or fully shrouded, and they may be made with helical teeth or with mortise teeth or of raw hide.

Gearing Chains. Gearing chains are used for transmitting power in cases where a flexible yet accurate drive is required. Their leading applications may be enumerated as follow: Driving steam-engine governors; driving line shafts from electric motors; driving motor-car axles; driving pumps and machine tools from electric motors; driving feed gears of machine tools; driving grain elevators and general conveyor work; travelling gear of steam and electric cranes; agricultural machinery, etc.; hoisting tackle for pulley-blocks and cranes. There are various types of gearing chains in use, and each type has its sphere of application more or less distinct from its fellows. The leading types are the *stud chain*, the *block chain*, the *bush roller chain*, and the *patent silent chain*.

The Stud Chain. Fig. **118** shows a heavy stud chain as used for hoisting tackle. It is designed for a working load of 10 tons, and a factor of safety of 10, consequently its breaking load would be 100 tons; a chain of this nature is designed simply for

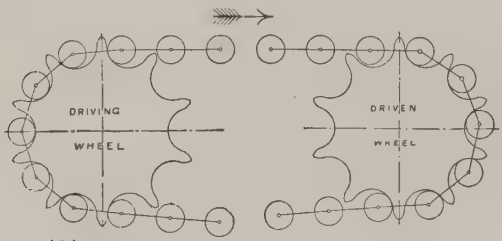


119. RENOLD SILENT CHAIN

strength, and has not sufficient wearing surface to render it suitable for transmitting power except at very slow speeds, not exceeding, say, 50 ft. per minute.

The Block Chain. This is suitable for speeds up to 500 ft. per minute. The block may be hollowed or flat; the design of this chain, as well as those which follow, is based upon the provision of ample wearing surface rather than upon actual strength; the proportions are settled by practice rather than by calculation. Accordingly, the selection of a chain for any particular duty is best left in the hands of expert manufacturers.

The Bush Roller Chain. Suitable for speeds up to 800 ft. per minute, the construction of this chain will be seen from **117**. The rivets of the chain carry hardened bushes, which form a

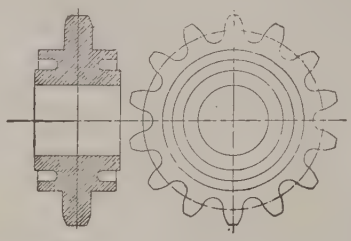


121. DIAGRAM OF CHAIN AND WHEELS

bearing for the anti-friction rollers which engage with the wheel teeth.

The Renold Silent Chain. With this chain 1250 ft. per minute can be attained [**119**]. The construction is unique, and the action of engaging with the wheel teeth is entirely different from ordinary chain gears. To understand this better, we will first investigate the action of ordinary chains and the formation of wheel teeth.

Fig. **120** illustrates a wheel suitable for working with the chain shown in **118**; the tooth curves are involute, and there is just enough space at the roots for the easy working of the studs as the chain enters and leaves the teeth. This is the simplest form, and works satisfactorily with slow speeds and uniform loads. As speeds increase and loads vary, this construction must be modified; the best-made chain will stretch, and then the wheel has to accommodate a varying and an increasing pitch. Another complication has also to be met: the driving wheel has a tendency to run faster than the chain, while the driven wheel tends to lag behind the chain; this effect is seen in **121**, which is slightly exaggerated in order to show the clearing allowances made. The pitch of the teeth is greater than the pitch of the chain in the case of the driving wheel, and the tooth spaces are much wider than actually required for the accommodation of the roller alone; by such construction the above-mentioned difficulties are overcome, but the life of the chain is seriously impaired if run beyond a speed of, say, 800 ft. per minute. The difference in pitch between the chain and the wheel gives rise to a series of little shocks as the load is transferred from tooth to tooth while running, such shocks being the cause of the wear and noise which considerably limit the speed.



120. STUD CHAIN WHEEL

Referring now to the patent silent chain [**119**], we see that the action of the links is to come quietly into position without slide or shock; when the teeth are worn, or when the chain is stretched, the chain rises automatically up the wheel tooth, as in **122**, and so accommodates itself to altered conditions, and maintains a silent drive. The chain consists of a number of links of the outline shown, there being from 4 to 12 abreast according to power transmitted. There are various modifications of construction adopted to suit different drives, but the above principles do not alter.

Chain Wheels. Chain wheels are ordinary castings for heavy stud chains, but are invariably machine-cut for all other types. The diameter of a wheel is naturally kept as small as possible, in order to keep the chain speed down, and also to save expense. When using *block chains*, the limit of teeth in the pinion may be taken as six, although smaller ones have been employed for special work. With *roller bush chains*, eight teeth are considered to be small enough for ordinary work, while the ratio of the wheel and pinion should not be more than 7 or 8 to 1. The smallest wheels for the patent silent chain should not contain less than 15 or 18 teeth, according to construction of chain; the *gear ratio* recommended should not be more than 5 to 1.

It is desirable to arrange a gear drive so that it contains an even number of links or pitches; when this is unattainable recourse is had to special links, as shown in the top right-hand corner of **117**, where they are cranked to fit outside of the links they would come abreast of.

Chain Belting. A chain belt is a form of metallic chain used largely for elevating and conveying machinery; the links are usually of malleable cast iron. The design and manufacture of this chain is even more in the hands of specialists than that of the foregoing type; consequently, the draughtsman is rarely called upon to design chain belting.

122.
RENOLD SILENT CHAIN WHEN WORN

Friction Wheels and Clutches. These are used for the transmission of power, at intermittent intervals, from constantly moving machinery; or for rapidly disconnecting a portion of moving mechanism; or for connecting machinery to an engine after it has been started up. A common application of

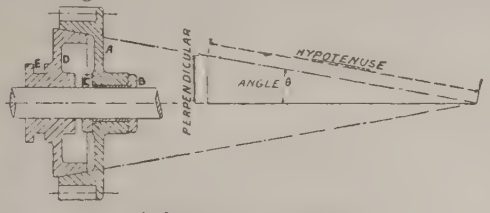
the latter form is met with on motor-car work, where the engine is not capable of starting up against full load.

The principles underlying this class of mechanism are discussed on page 1303, and applications are illustrated on pages 1305 and 1308 in MECHANICAL ENGINEERING. We therefore proceed to delineate more fully several leading types.

Fig. 123 shows a flat-faced friction wheel and pinion as used on a friction hoist. The wheel is keyed to the rope-barrel of the hoist, and the barrel runs loose upon the shaft. The end of the shaft is formed eccentrically, and is moved through a portion of an arc by means of the lever and cord. This movement brings the friction wheel into contact with its pinion, which latter is running constantly; the friction set up between the two surfaces causes the wheel to revolve. The barrel, being keyed to the wheel, must go with it, and so the load is lifted. The calculations involved are simple, and may be stated thus: The load to be lifted is 1 ton; the corresponding load on the periphery of the wheel is

$$\frac{\text{load} \times \text{A}}{\text{B}} = \frac{2240 \times 9}{15} = 395 \text{ lb.}$$

Assuming the coefficient of friction to be ·2 (cast



124. FRICTION CONES

iron on cast iron), then the pressure required between the wheel and pinion is

$$\frac{395}{\cdot 2} = 1975 \text{ lb.},$$

and the load on the operating cord is therefore

$$\frac{1975 \times \text{C}}{\text{D}} = \frac{1975 \times \cdot 75}{70} = 21 \text{ lb.}$$

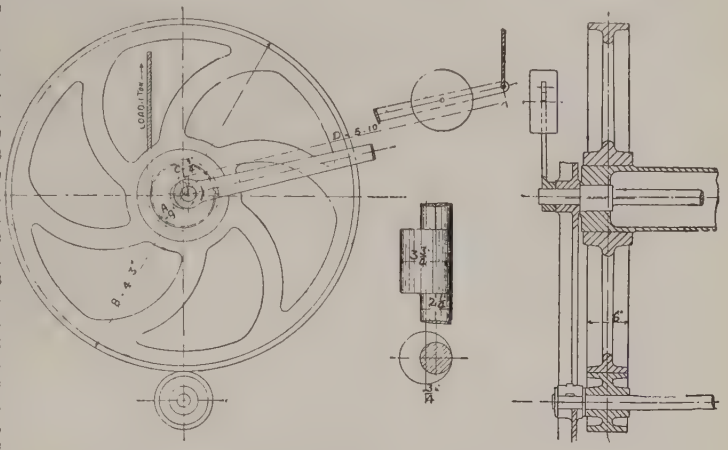
which is quite within the capacity of an average man to manipulate. The pulleys are designed as ordinary belt pulleys, but are somewhat heavier throughout, to withstand shocks due to the sudden application of the load. An enlarged view of the eccentric formation of the shaft is given in 123, which illustrates a neat way of making a very short lever arm.

The weight near the end of the long lever is so placed in order to ensure the large pulley returning to contact with a brake block arranged overhead when the hand cord is released. The width of the wheel is 6 in. in the case illustrated, and this works out to

$$\frac{1957}{6} = 329 \text{ lb. per inch of width.}$$

This represents average practice. High pressures per inch of width tend to heat the pulleys.

Friction Cones. Friction cones or *cone-couplings* are used for coupling shafts while one of the shafts is running, or for taking power from a revolving shaft. The latter application is shown in 124, the view illustrated being a section, and all portions circular. The outer cone piece, A, is bushed and runs

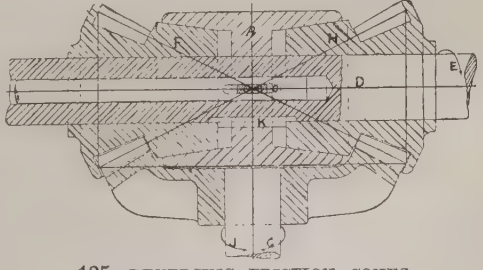


123. FRICTION WHEELS

loose on the shaft, being kept in its place endwise by means of the collars, B and C. Teeth are cast on the outside periphery, which engage with corresponding teeth of a spur wheel. The inner cone piece, D, slides upon feathers fitted in the shaft, and is moved by suitable lever gear fitted to the groove, E. Driving of the spur gear takes place when the cones are pressed together with sufficient force to overcome the resistance to slipping between their surfaces. The end pressure required depends upon the coefficient of friction and upon the angle of the cone. The general formula in use is

$$\text{P} = \frac{\text{L} \times \text{sine } \theta}{\mu},$$

where P is the necessary end pressure. L is the load to be transmitted at the mean diameter of the cone. θ is used to denote the angle; "sine" is the trigonometrical ratio of the angle θ, and is found by dividing the perpendicular by the hypotenuse; μ denotes coefficient of friction. The

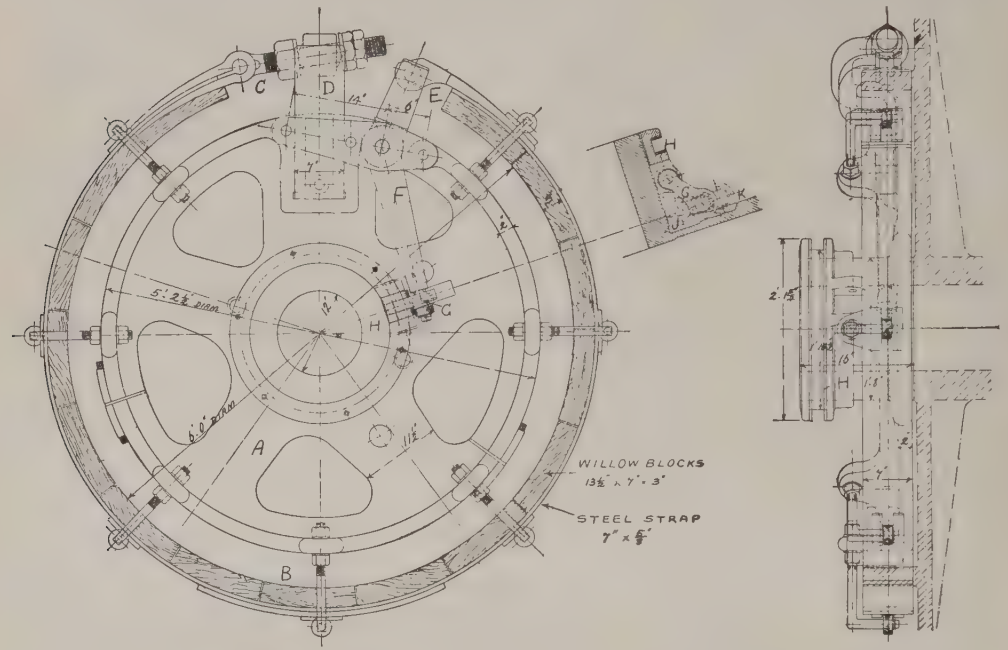


125. REVERSING FRICTION CONES

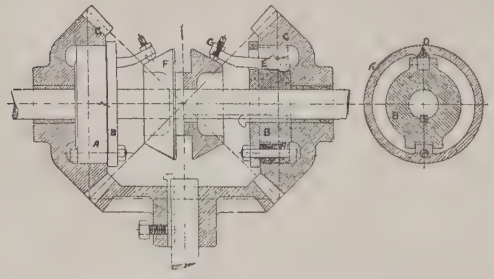
angle θ is usually 10 deg., and μ may be taken as ·2 for cast iron on cast iron.

Reversing Cones. Another application of the foregoing type of cones is shown in 125. The outer cone, A, is in this case driven from the shaft by means of the cottar, B, which passes through a slot, C, in the shaft. This cottar also passes through a central rod which is moved endwise at the centre of the shaft. The outer cone is double-ended, in

order to engage with either the right or left hand inner cones, and these latter are each cast in one piece with a bevel pinion, and both pinions gear into a single bevel wheel; the shaft, D, runs continuously, and carries the outer cone with it. When the shaft is running in the direction of the arrow, E, and the cone, F, is engaged, then the bevel wheel runs in the direction of the arrow, G; but if the cone, H, be engaged, then the bevel wheel revolves in the direction of arrow, J. The central rod device can only be used when the cones are located a short distance from the end of the shaft. Failing this, they may be moved, as in the case of **124**, by forming the groove around the centre of the outer cone. The feather, K, assists to drive the outer cone, and its ends keep the inner cones at their proper distance apart. Sometimes collars are fitted at the ends of the feather in order to prevent the ends of the cones from being cut by the feather.



126. THE "WELLMAN SEAVER MORGAN" CLUTCH



127. EXPANDING RING CLUTCH

Friction Clutches. The principal objection to the use of the friction devices just described is the resulting end pressure upon the bearings of the shafting. Figs. **126** and **127** show two friction clutches which are practically free from this defect.

An *expanding ring clutch* is seen in **127**. It is double-ended or reversible. The expanding ring, A, is driven from the shaft by key and by the piece, B. It is expanded to drive the hollow of the mitre wheel, C. In order to effect the expansion, the ring is divided at D, and receives a steel wedge piece, which is forced up by another wedge formed on the lever, E. This lever is moved by striking the cone piece, F, to the right or to the left. The angles of the wedges and of the cone are such that they slip back when the pressure is removed. The adjusting screw, G, on the end of the lever provides means for following up the wear on the working parts, and so keeping the relative stroke of the cone a constant.

A friction clutch which has wide applications amongst mill work and winding engines, and can be built to transmit thousands of horse-power, is shown in **126**. It is made by the Wellman Seaver Morgan Co., Ltd. It consists of a centre driving disc, A, which is keyed to the shaft, and carries with it a wood-lined strap, B, which is adjustable by means of its anchored end, C, on a driving piece, D, and is tightened by the end marked E and the lever, F, the tail end of which has a spherical connection with the link, G. The sliding collar, H, is moved by suitable striking levers, and causes the link, G, to move the ball end of the lever, F, from position J to position K. The strap is thus tightened upon the rim of any drum or wheel which may be interposed between the strap and the driving disc, A, as shown in chain-dotted section. Such interposing rim does not have any contact with disc A.

The leading dimensions of one of these clutches are given on the drawing [**126**], which is 6-ft. diameter, and can transmit 11-horse power per revolution, with a maximum load of 20,000 lb. on the rim.

JOSEPH W. HORNER

Use of Subjunctive. Sequence of Tenses. Agreement of Past Participle. Remarks on Adverbs, Prepositions, and Conjunctions.

FRENCH

Continued from page 5534

By Louis A. Barbé, B.A.

VERBS

Use of the Subjunctive—continued

5. The verb must be in the subjunctive when it is preceded by a relative pronoun having for its antecedent a noun qualified by a superlative, or by some word equivalent to a superlative, such as: *le premier*, the first; *le dernier*, the last; *le seul*, the only: *Le chien est le seul animal dont la fidélité soit à l'épreuve*, The dog is the only animal whose fidelity can be relied on (lit. is proof).

When the superlative is followed by an indirect object the verb is in the indicative: *Le soleil est le plus grand des corps que l'on aperçoit dans le ciel*, The sun is the largest of the bodies that we perceive in the heavens.

6. After *quel que* (*quelle que, quels que, quelles que*), whatever; *qui que*, whosoever; *quoi que*, whatsoever, the subjunctive is required in the subordinate clause: *Quel que soit le mérite d'un homme, il ne peut échapper à l'envie*, Whatever a man's merit may be, he cannot escape envy.

7. *Quelque . . . que*, and *si . . . que*, meaning whatever, however, require the verb following them to be in the subjunctive: *Quelque effort que fassent les hommes, leur néant paraît partout*, Whatever effort men may make, their nothingness is everywhere apparent.

8. When *que* is used to avoid the repetition of *si*, the verb that follows it must be in the subjunctive: *Si vous passez par cette ville et que vous puissiez disposer d'une couple de jours, ne manquez pas de vous y arrêter*, If you pass through that town, and if you can spare a couple of days, do not fail to make a stay there.

9. The subjunctive is used (*a*) after conjunctions indicating time before which, or time up to which, as *avant que, en attendant que, jusqu'à ce que*; (*b*) after conjunctions indicating purpose or result, as *afin que, pour que, de crainte que, de peur que*; (*c*) after conjunctions implying a condition or supposition, as *en cas que, au cas que, à moins que . . . ne, pourvu que, supposé que*; (*d*) after conjunctions implying a concession, as *quoique, bien que, encore que, soit que . . . soit que; soit que . . . ou que; pour peu que, si tant est que*; and (*e*) after conjunctions involving a negation, as *non que, non pas que, loin que, sans que*:

(*a*) *Je lui ai payé cette somme avant qu'il partît*, I paid him that amount before he left.

(*b*) *Ce livre est toujours sur le bureau, afin qu'on puisse le consulter*, That book is always on the desk, so that it may be consulted.

(*c*) *Pourvu qu'on sache la passion dominante de quelqu'un, on est assuré de lui plaire*, Providing we know the master-passion of any one, we are sure to please him.

(*d*) *Quoiqu'il soit pauvre, il est un honnête homme*, Although he is poor, he is an honest man.

(*e*) *Je dis cela, non que je veuille me plaindre, mais pour que vous sachiez ce qui s'est passé*, I say this, not that I wish to complain, but that you may know what has taken place.

10. The subjunctive occurs in elliptical sentences expressing a wish or a command; and, in such cases, the conjunction *que* is sometimes omitted: *Que Dieu vous ait en sa sainte garde*, May God have you in His holy keeping; *Vive le Roi!* Long live the King!

11. The subjunctive is used idiomatically in the expression *je ne sache*, followed by a negation, and *que je sache*, preceded by one: *Je ne sache rien qui soit plus digne de notre amour que la vertu*, I know of nothing that is more worthy of our love than virtue; *Cette affaire ne le regarde nullement, que je sache*, This matter does not concern him in any way that I know of.

Sequence of Tenses. 1. When the verb of the governing clause is in the present, whether indicative, subjunctive, or imperative, or in either of the future tenses of the indicative, the verb of the subordinate clause must be in the present subjunctive if it be intended to express an action or a state considered as either present or future in respect of the governing verb: *Il faut que je sorte maintenant*, I must go out now.

2. When the verb of the governing clause is in the present, whether indicative, subjunctive, or imperative, or in the future indicative, the verb of the surbordinate clause must be in the perfect subjunctive if it be intended to express an action, or a state considered as past in respect of the governing verb: *Je ne crois pas que vous ayez fait tous vos efforts*, I do not think you have done your utmost.

3. When the verb of the governing clause is in any past tense of the indicative or subjunctive, or in either tense of the conditional, the verb of the subordinate clause must be in the imperfect subjunctive if it be intended to express an action or a state considered as either present or future in respect of the governing verb: *Je voulais qu'on retardât le départ*, I wished the departure to be delayed.

4. When the verb of the governing clause is in any past tense of the indicative or of the subjunctive, or in either tense of the conditional, the verb of the subordinate clause must be in the pluperfect subjunctive if it be intended to express an action or a state considered as past in respect of the governing verb: *Je ne savais pas que vous m'eussiez écrit*, I did not know that you had written to me.

5. When the verb of the governing clause is in the past indefinite, the verb of the subordinate clause is frequently put in the past subjunctive instead of the pluperfect subjunctive: *Il a fallu qu'il se soit donné bien des peines*, He must have given himself a great deal of trouble.

6. A past indefinite in the governing clause may be followed by a present subjunctive in the subordinate clause to express an action or a state which is still present: *Cet auteur n'a employé aucune fiction qui ne soit une image de la vérité*, That author has used no fiction that is not an image of truth.

Agreement of the Past Participle

1. The past participle, when not accompanying an auxiliary verb, is practically an adjective, and agrees in gender and number with the noun or pronoun to which it refers: *Voyez-vous là-bas ces collines couronnées de bois sombres?* Do you see yonder those hills crowned with dark woods?

Exception: A certain number of past participles really become prepositions when they precede a substantive, and are then invariable. The chief of them are: *attendu*, considering; *vu*, seeing; *excepté*, except; *y compris*, including; *ci-inclus*, enclosed: *Excepté vous et moi*, Except you and me.

These participles agree in the ordinary way when they come after the noun or pronoun to which they refer: *Vous et moi exceptés*, You and I excepted.

2. When the past participle is accompanied by the verb *être*, to be, as is the case in all the tenses of passive verbs and in the compound tenses of some neuter or intransitive verbs, it always agrees in gender and number with the subject of the verb: *La vertu obscure est souvent méprisée*, Obscure virtue is often despised.

3. When the past participle is used in connection with *avoir*, to have, to form the compound tenses of an active verb, it agrees in gender and number with the direct object of the verb, providing that direct object precedes the verb: *J'ai reçu toutes les lettres que vous m'avez adressées*, I have received all the letters which you have addressed to me.

In this example *reçu* does not agree with the direct object, because that object—*i.e.*, *toutes les lettres*—comes after it. *Adressées*, on the other hand, agrees with its direct object *que*, because that direct object precedes it.

4. It follows from this rule that, as a neuter verb cannot have a direct object, its participle is always invariable: *La justice et la modération de nos ennemis nous ont plus nui que leur valeur*, The justice and moderation of our enemies have done us more harm than their valour. In this example, the neuter verb *nuire* (= to injure, to do harm) governs *nous* in the dative, or indirect object. There can, consequently, be no agreement.

5. Pronominal, or reflexive, verbs are conjugated in their compound tenses with the help of *être*, to be. This auxiliary, however, is equivalent to *avoir*, to have; and the rule for the agreement of the past participle is the same as in the case of the past participle conjugated with *avoir* [see above, 3]: *Ces hommes se sont repentis*, Those men have repented. In this sentence *se* is the direct object of the pronominal verb *se repentir*, to repent; and consequently the past participle agrees with it.

Elle s'est plu à me contredire, She delighted in contradicting me. In this example, the pronominal verb *se plaire*, to delight in, is made from the intransitive verb *plaire*. The pronoun s' (= *se*) is governed by it in the dative. Consequently there is no agreement.

Nous nous sommes lavé les mains, We have washed our hands. Here the direct object of the pronominal verb *se laver* is the noun *mains*; and, as it does not precede the verb there is no agreement. On the other hand, the past participle agrees with the second *nous* in the following example, where it is the direct object: *Nous nous sommes lavés*, We have washed (ourselves).

6. The past participle of an impersonal verb, or of a verb used impersonally, can never have a direct object with which to agree: *Les chaleurs qu'il a fait pendant l'été*, The heat which was experienced during the summer. Here *il a fait* (= it has made) is used impersonally and idiomatically to indicate existence (= there has been).

7. The past participle *été* never changes under any circumstances: *La maison a été brulée*, The house was burnt. *Nous sommes ce que nous avons toujours été*, We are what we always have been.

Special Cases. 1. When the past participle conjugated with the auxiliary *avoir* and preceded by a direct object is followed by an infinitive, that past participle agrees with the object if it is the governing verb. It does not agree if the infinitive is the governing verb: *Les dames que nous avons entendues chanter*, The ladies whom we heard sing (singing). Here, the past participle agrees because it belongs to the verb governing *que*, whom. It is to be noted that in this case, the French infinitive *chanter* may be translated by the English present participle *singing*.

Les airs que nous avons entendu chanter, The melodies which we heard sung. Here the past participle does not agree, because not it, but *chanter* is the verb governing *que*. It is to be noted that in this case the French infinitive is translated by the English past participle *sung*.

The past participle *fait* does not come under this rule. When immediately followed by an infinitive it always remains unchanged (*fait*): *Une femme s'est présentée à la porte; je l'ai fait passer*, A woman presented herself at the door; I made her pass in.

2. It frequently happens that a governing infinitive is understood after the past participles of *devoir*, *vouloir* and *pouvoir*—*i.e.*, *dû*, *voulu*, *pu*. In that case the past participle does not agree with the preceding object: *Je lui ai rendu tous les services que j'ai pu*, I have rendered all the services which I could (*i.e.*, render him).

3. A past participle preceded by the relative pronoun *que*, and followed by the conjunction *que*, never agrees with the relative: *Les lettres que j'ai prévu que vous recevriez*, The letters which I foresaw you would receive.

4. The past participle does not agree with *en*, some, any: *Il a acheté plus de livres qu'il n'en a lu*, He has bought more books than he has read.

The past participle preceded by *en* may, however, agree with some other word also preceding it: *J'ai reconnu la maison d'après la description que vous m'en avez faite*, I recognised the house from the description you gave me of it.

5. After *le peu* the past participle remains unchanged if *le peu* is equivalent to "the want of": *Le peu d'affection que vous lui avez témoigné l'a découragé*, The little affection you showed him discouraged him.

If, on the contrary, *le peu* represents a positive quantity, a certain amount, the past participle agrees with the complement of *le peu*—*i.e.*, the noun coming after it: *Le peu d'affection que vous lui avez témoignée l'a encouragé*, The little affection you showed him encouraged him.

ADVERBS

Negation. 1. Negation is usually expressed by *ne* and *pas*, or *point* (which is rather stronger than *pas*). *Ce n'est pas moi qui vous l'ai dit*, It is not I who told you.

2. The second part of the negation is omitted after *savoir*, used with the meaning of *pouvoir*, to be able: *Je ne saurais en venir à bout*, I cannot manage it. In this construction the present conditional of *savoir* is used instead of the present indicative of *pouvoir*.

3. When *savoir* has its ordinary meaning of "to know" it requires *pas* when used negatively: *Il ne sait pas le français*, He does not know French.

4. When a verb used negatively is followed by a negative relative clause, that relative clause takes *ne* only: *Il n'y a personne qui ne le respecte,* There is no one but respects him.

5. When the negation is expressed by any word but "not," such as "never," "nobody," "nothing," etc., *ne* is used, but *pas* must be omitted: *Je ne dois rien,* I owe nothing.

6. In negations the order of the words is usually: first, *ne;* second, verb; third, second part of the negative expression. But when "nobody" or "nothing" is the subject of the sentence, *personne,* or *rien,* must precede *ne*: *Personne n'a voulu lui parler,* Nobody would speak to him.

7. "Neither—nor" must be expressed by *ne—ni*: *Elle n'a ni frère ni sœur,* She has neither brother nor sister.

8. Several negative expressions may occur in the same sentence, in which case *ne* is used only once: *Personne ne m'a jamais rien dit,* Nobody has ever said anything to me.

9. *Ne* is used alone and without any negative meaning: (*a*) After verbs and other expressions indicating fear: *Je crains que vous ne perdiez votre argent,* I fear you will lose your money. (*b*) After *que,* "than," in comparisons of superiority or inferiority having a verb for their second term: *Vous écrivez mieux que vous ne parlez,* You write better than you speak. (*c*) After *à moins que,* "unless": *J'irai me promener, à moins qu'il ne fasse mauvais temps,* I shall go for a walk unless it is bad weather.

Special Remarks. 1. *Auparavant* and *avant* both mean "before" (of time); but *auparavant* being an adverb has no complement, whilst *avant,* which is a preposition, requires one: *Nous lui avions déjà écrit quelques mois auparavant,* We had already written to him a few months before; *Je le verrai avant vous,* I shall see him before you.

2. *Davantage* and *plus* both mean "more," but *davantage* must not be followed by *que* nor by *de.* It therefore stands only at the end of a sentence: *Vous avez de l'argent, mais il en a davantage,* You have money, but he has more.

3. *Dessus,* "on, over"; *dessous,* "under, underneath"; *dedans,* "within, in"; *dehors,* "without, out," which are adverbs and take no complement, are to be carefully distinguished from the corresponding prepositions *sur, sous, dans, hors,* which require complements. These adverbs are frequently used instead of a preposition and a pronoun referring to an inanimate object: *Nous ouvrîmes la boîte, mais il n'y avait rien dedans,* We opened the box, but there was nothing in it.

4. *Plus tôt* and *plutôt* both mean "sooner," but *plus tôt* refers to priority of time, whilst *plutôt* indicates preference: *Il est revenu plus tôt que je ne croyais,* He has come back sooner than I thought; *Donnez-nous la mort plutôt que l'esclavage,* Give us death rather than slavery.

5. *Au moins* and *du moins* both mean "at least," but *au moins* indicates a minimum, whilst *du moins* corrects or limits a former statement: *Ce voyage vous coûtera au moins mille francs, du moins c'est ce qu'il m'a coûté l'année dernière,* That journey will cost you at least forty pounds—at least, that is what it cost me last year.

PREPOSITIONS

1. Prepositions, with the single exception of *en,* require verbs that follow them to be in the infinitive. After *en* the verb must be in the present participle: *En voyant son père il se mit à pleurer,* On seeing his father he began weeping.

2. The prepositions *à, de,* and *en* must be repeated before each complement: *Il dut la vie à la clémence et à la magnanimité du vainqueur,* He owed his life to the clemency and the magnanimity of the victor.

3. Other prepositions are usually repeated when the complements are opposed to each other in meaning: *Dans la ville et dans la campagne,* in town and country.

4. The prepositions *jusque,* as far as; *attenant,* adjoining; *par rapport,* with regard to; *quant,* as to, require the preposition *à* after them: *Il nous a accompagnés jusqu' à Londres,* He accompanied us as far as London.

But when *jusque* is construed with *où, ici, là, dans,* and *chez* it does not take *à* as well: *Il nous a accompagnés jusque chez nous,* He accompanied us as far as our house.

5. The preposition *de* is required after *auprès,* near; *autour,* around; *loin,* far; *près,* near; and *proche,* close, as well as after prepositional phrases, including a noun, as *à force,* by dint: *Ils demeurent près de l'église,* They live near the church.

6. *Avant* (before) requires no preposition before a noun or pronoun, but takes *de* before a verb: *Viendrez-vous nous voir avant de partir?* Will you come and see us before leaving?

7. When helping to form compound words, the preposition *à* conveys the idea of fitness, agency, peculiarity: *Un bateau à vapeur,* a steamboat.

8. The preposition *de* is joined to a noun of material to form a qualifying phrase: *Un chapeau de paille,* a straw hat.

9. The preposition *de* is used after *plus* and *moins* to express "than" before a numeral: *Vous avez plus de dix fautes,* You have more than ten mistakes.

10. The preposition *de* is used before *plus* and *moins* to express "more" and "less," when those words follow a numeral with a noun expressed or understood: *Vous avez douze fautes; il en a deux de moins,* You have twelve mistakes; he has two less.

11. The preposition *de* is used for "by" in expressions indicating excess or difference: *Vous le dépassez de toute la tête,* You are taller than he (exceed him) by a whole head.

12. The preposition *de* is used for "with" after verbs and adjectives expressing plenty, want, providing, depriving, etc.: *Il s'était rempli les poches de petits cailloux,* He had filled his pocket with little pebbles.

13. When a cardinal number is preceded by *en,* the adjective or past participle that follows that numeral usually takes *de*: *Sur cent habitants, il y en a deux de riches,* Out of a hundred inhabitants there are two rich.

14. When the verb "to be" has an infinitive coming after it for its logical subject that infinitive takes *de* or *que de* before it: *C'est mal de* (or *que de*) *parler comme cela,* It is wrong to speak so.

15. An infinitive following "than" takes *de* before it: *Il mourrait plutôt que de trahir sa patrie.* He would die rather than betray his country.

16. When a noun or an adjective used substantively serves as an epithet to qualify another noun, *de,* meaning "of a," is put before the qualified noun: *Un drôle d'individu,* a queer fellow.

17. The essential difference between *en* and *dans* is that *en* is only exceptionally used with the definite article *le, la, les,* whilst *dans* always requires it. Consequently nouns following *en* have usually an indeterminate meaning: *On l'a mené en prison,* He has been taken to prison; *On lui a permis*

d'entrer dans la prison, He was allowed to enter the prison.

18. *En* frequently means "in the character of," "like": *Vous parlez en soldat; je dois agir en roi,* You speak as a soldier; I must act as a king.

19. In expressions of time there is a great difference between *en* and *dans*. *En* indicates "time, how long," whilst *dans* indicates "point of time when": *Je ferai cet ouvrage en deux jours,* I shall take two days to do that work; *Je ferai ce travail dans deux jours,* I shall begin doing that work two days from now.

20. *En* is used in connection with all the seasons except spring, which takes *au*: *Il fait moins chaud au printemps qu' en été,* It is less warm in spring than in summer.

21. *À travers* and *au travers* both mean "through," but *à travers* means "through" in the sense of "across"; whilst *au travers,* which is always followed by *de,* rather means "right through," and implies a greater effort: *Nous courûmes à travers les champs,* We ran through the fields; *Il se fraya un passage au travers de la haie,* He forced his way through the hedge.

22. *Vers* and *envers* both mean "towards"; but *vers* refers to direction, whilst *envers* is used figuratively, in connection with feeling, sentiment, etc.: *Le premier moment de la vie est le premier pas vers la mort,* The first moment of life is the first step towards death; *Il s'est montré ingrat envers ses bienfaiteurs,* He showed himself ungrateful towards his benefactors.

CONJUNCTIONS

1. The conjunction *ni,* "neither," may be either used or omitted before the first of several subjects: *Le soleil ni la mort ne se peuvent regarder fixement,* Neither the sun nor death can be steadfastly gazed at; *Ni l'or ni la grandeur ne nous rendent heureux,* Neither gold nor greatness makes us happy.

2. The conjunction *ni* may be used to avoid the repetition of *sans,* "without"; *Sans crainte ni pudeur,* or *sans crainte et sans pudeur,* without fear or shame.

3. The English expressions "nor . . . either" "not . . . either," are to be translated by *ni . . . non plus, ne . . . pas non plus*: *Je ne le connais pas, ni elle non plus,* I do not know him nor her either; *Je ne lui écris pas, et il ne m'écrit pas non plus,* I do not write to him, and he does not write to me either.

4. The expression "either . . . or" may be expressed either by using *ou* before each term, or omitting it before the first: *Le ciel n'est ouvert ou qu'aux innocents ou qu'aux pénitents,* Heaven is open either to the innocent only, or the penitent only; *Le bonheur ou la témérité ont pu faire des héros,* Either good fortune or rashness may have produced heroes.

5. *Soit* and *soit que* both mean "whether," but *soit* precedes a noun, whilst *soit que* is followed by a verb. Both of them may be repeated before each term, or replaced by *ou* or *ou que* before the second: *La fortune, soit bonne ou mauvaise, soit passagère ou constante, ne peut rien sur l'âme du sage,* Fortune, whether good or bad, whether fleeting or constant, has no power on the soul of the wise man.

6. The conjunction *que* may be used to prevent the repetition of either *comme,* as: *quand,* when; or *si,* if. When replacing the last of these, it requires the verb that follows it to be in the subjunctive: *Comme nous l'avons déjà dit et que nous le verrons plus clairement ailleurs,* As we have already said, and as we shall see more clearly elsewhere; *Quand on est jeune et qu'on se porte bien on devrait aimer les exercices du corps,* When we are young, and are in good health we ought to like bodily exercise; *Si vous le rencontrez et que vous lui parliez, faites-lui mes amitiés,* If you meet him and speak to him, give him my kind regards.

7. *Que* may be used instead of *afin que,* in order that; *sans que,* but that; *lorsque,* when; *depuis que,* since; *de peur que,* lest; and *avant que,* until: *Approchez que je vous parle,* Draw near, that I may speak to you; *Je n'irai pas me coucher que ma besogne ne soit finie,* I shall not go to bed until my task is ready.

8. When, however, *que* takes the place of a conjunction which does not itself require the subjunctive (except the conjunction *si*), it is not followed by the subjunctive: *Je le ferai quand je serai revenu, et que j'aurai le temps,* I shall do it when I have returned and have the time.

Translation

BONNES RÉSOLUTIONS

Si je me lève tard et que je traîne tout le jour, je commencerai à peine mon ouvrage à la nuit; mais je me coucherai tôt, je me lèverai tôt, et j'obtiendrai par ce moyen, santé, richesse et sagesse. Je m'efforcerai d'être laborieux, afin que je n'aie jamais à craindre la disette (want). Il n'est pas nécessaire que je trouve un trésor, ni qu'il m'arrive un riche héritage; mon activité me suffira. Je travaillerai dès aujourd'hui, car je ne sais pas si je n'en serai pas empêché demain. Je rougirai de ne rien faire, alors que j'ai tant à faire pour moi-même, pour ma famille, pour mon pays. Je prendrai mes outils sans mitaines et je me souviendrai que chat ganté ne prend pas de souris. Peut-être me sentirai-je parfois le bras trop faible; mais je tiendrai ferme et je triompherai de tous les obstacles. J'emploierai bien mon temps, parce que je veux gagner du loisir et comme je ne suis pas sûr d'une minute, je ne perdrai pas une heure.

KEY TO TRANSLATION

GOOD RESOLUTIONS

If I get up late and dawdle (drag) all day, I shall hardly begin my work at night; but, I shall go to bed early, I shall get up early, and I shall obtain by that means health, wealth, and wisdom. I shall strive to be industrious, so that I may never have to fear want. It is not necessary that I should find a treasure, nor that a rich legacy should come to me; my activity will suffice me. I shall work from this very day, for I do not know whether I shall not be prevented from (doing) it to-morrow. I shall blush to do nothing when I have so much to do for myself, for my family, for my country. I shall take up my tools without mittens, and I shall remember that a gloved cat catches no mice. Perhaps I shall sometimes feel my arm too weak; but I shall hold fast, and I shall triumph over all obstacles. I shall make good use of my time, because I wish to win leisure, and as I am not sure of a minute I shall not lose an hour.

FORTY THOUSAND BARRELS OF OIL A DAY

LAKE VIEW GUSHER, IN CALIFORNIA, WHICH REACHED A HEIGHT OF OVER 300 FEET, AND POURED OUT OIL AT THE RATE OF OVER 40,000 BARRELS A DAY

By courtesy of "The Scientific American"

FACING PAGE 5661

The Source and Nature of Petroleum. Inorganic and Organic Theories. How Petroleum was Formed. The Nature of Petroleum Beds.

PETROLEUM

PETROLEUM, a Latin term meaning rock oil, is a general name for a wide variety of kindred mineral substances, ranging from wholly opaque to transparent, from semi-solid to extremely fluid, and from odourless to agreeably aromatic or highly offensive, all combustible, but with very different degrees of inflammability, and only in rare instances fit for use in any way without previous treatment.

The Petroleum Act, 1871 (34 and 35 Vict., ch. 105), which is still in force, except as to the standard of flash-point, and the mode of testing [see Methods of Testing, in a later chapter], defines *petroleum* in the following words: "For the purposes of this Act the term 'petroleum' includes any rock oil, Rangoon oil, Burma oil, oil made from petroleum, coal, schist, shale, peat, or other bituminous substance, and any products of petroleum, or any of the above-mentioned oils; and the term 'petroleum to which this Act applies' means such of the petroleum so defined as, when tested in the manner set forth in Schedule I. to this Act, gives off an inflammable vapour at a temperature of less than 100° of Fahrenheit's thermometer." It will thus be seen that the legal definition of petroleum is a wide one, embracing liquid products, such as coal-tar, and the solid product, paraffin, which are not "petroleum" in the commercial acceptation of that term. The reference to Rangoon oil and Burma oil doubtless had its origin in the circumstance that shortly before the Act was passed the produce of the Burma oil-fields was in small quantities brought to this country, petroleum having previously been imported only from the United States. The name of Rangoon oil was derived from the port of shipment, "Rangoon oil" and "Burma oil" being two names for the same product. Petroleum now comes to the United Kingdom from many other countries, and there is less reason for retaining the specific mention of Rangoon oil or Burma oil than for specifying Russian oil or the oils of Rumania and Borneo.

Crude Petroleum Oils. Crude oils, as collected, invariably consist of mixtures of several allied compounds, with, not infrequently, other substances, either dissolved in them, or mechanically enclosed and retained in suspension. They may be roughly classified as illuminating oils and fuel oils, according to the preponderance of one or other of these distinct groups of compounds in the natural admixtures, or in blends resulting from indiscriminate collection. The crude oils are further divided into asphalt-base and paraffin-base oils, according to the nature of the more solid matter held in solution by the more fluid, and determining the quality and use of the residue left on distilling off the lighter oils. The paraffin-base oils must not, however, be confounded with the ordinary burning oil (kerosene or paraffin oil), as the latter is largely made from asphalt-base crude oil. Petroleum was at one time called coal-oil, partly because a kindred substance could be prepared by distillation from coal, but chiefly from a mistaken idea that, being combustible, it must necessarily be derived in some unexplained way from coal seams. The term fell into disuse when it was found that not only did no such relation exist, but that oil-bearing rocks and coal rarely occur in the same geological series of strata.

The Origin of Petroleum. Much controversy has arisen upon the origin of these various compounds, some contending for their production by purely chemical action, deep in the unknown interior of the earth, and their ascent as vapour to be cooled and reduced to fluid or solid nearer the surface.

The distinguished Russian chemist Mendeléeff [see pages 442 and 710] gave the weight of his authority to the view that petroleum is of inorganic origin. The great density of the earth, the well-known presence of iron carbide in meteorites, as well as of iron in the solar system, as shown by the spectroscope, and the presence of iron in basalts and other eruptive rocks, were adduced by him as powerful arguments in favour of the assumption that the interior of the earth contains large amounts of iron, whether combined with carbon or not. Proceeding upon this assumption, he ascribed the formation of petroleum to the action of carbide of iron at high temperatures in the interior of the earth upon water which has penetrated through fissures produced in the earth's crust by the elevation of mountain chains or other changes of structure which have occurred.

On the other hand, the equally illustrious French chemist Berthelot [see pp. 310 and 442], accepting the hypothesis that the interior of the earth contains free alkali metals, ascertained by experiment that when carbonic acid or an earthy carbonate acts upon the alkali metals at a high temperature in the presence of water-vapour, chemical changes occur, which result in the production of hydrocarbons similar to those of petroleum, the exact composition of the hydrocarbons varying with the temperature. He therefore expressed the view that petroleum may have been produced by the infiltration of water containing carbonic acid gas into the interior of the earth, where it would be brought into contact with the alkali metals at an elevated temperature, and under great pressure, with the production of both liquid and gaseous petroleum.

Neither of these hypotheses is tenable, in view of the facts of the geological structure and composition of the rock-beds constituting the oil-bearing series in any part of the world.

Theories of Organic Origin. Two other schools exist of disputants on the origin of petroleum, each having amassed a sufficient body of evidence in support of animal origin in one case, of vegetable derivation in the other, to convince its partisans that the view propounded, if not of universal applicability, holds good in at least the great majority of oil-fields. The vast quantities of animal and vegetable remains stored in limestones and clays of various geological periods, and the legitimate assumption that where the rocks are not so rich in fossils their absence is due to want of preservative conditions rather than deficiency of life at the time of formation, indicate an ample supply of organic material at all periods of the

earth's history, as represented by stratified deposits; its decomposition generally, and its conversion into petroleum more rarely, being dependent on the conditions prevalent at the time and place of embedding in the strata, while the subsequent upheavals and removals of vast masses of material (to constitute the newer deposits) would tend to waste much of the earlier-formed oil, traces of which remain as asphalt or other bitumen, even in rocks of extreme antiquity, and in nearly every country in the world. As the adherents of the hypothesis of vegetable origin base their views generally on observations taken in different regions from those referred to by the exponents of animal origin, there is every probability that both schools are right in the main thesis, though wrong in insisting on its universality. The animal remains of the Ohio limestones have produced a different oil from that of the vegetable matter embedded in the somewhat later sandstones of the adjacent State of Pennsylvania. In each region, and for each geological period, the chief or sole factor is to be determined independently, and in many cases both animal and vegetable remains may have been contributory to the same store of petroleum.

Proof of Organic Origin. The most noted exponents of the view that petroleum is solely or mainly of animal origin are Höfer and Engler. In a series of experiments the latter obtained, by the distillation of menhaden (fish) oil at a high temperature and under considerable pressure, a product resembling petroleum. The distillate yielded by fractionation a lighting oil which was described as indistinguishable from commercial kerosene, and this statement the author of these articles, having received a sample of the product many years ago from Professor Engler, is in a position to confirm.

Oil is still being formed in various parts of the world, in some places from animal, in others from vegetable remains, though it is not known that any great bulk of it is produced, or any whatever preserved. For such storage the production must necessarily take place under conditions precluding the possibility of observation, and beyond the range of our present knowledge to imagine with any approximation to definite conception.

Bitumen, or some similar residue of evaporated petroleum, occurs, as we have seen, in even the oldest rocks, but oil of commercial value first appears in those of the Silurian epoch [see GEOLOGY]. From this early period down to nearly the present era valuable oil-fields occur, at one point or other, in every division of the geological series. Probably the Miocene period was the richest in petroleum-forming conditions, a magnificent birthday endowment for the human race, then in the earliest stages of its biped evolution.

Mode of Occurrence of Petroleum. Two classes of rock combine to furnish the vast and ever-increasing quantity of petroleum annually consumed. These are coarse sands (or sandstones) and crystalline limestones, both of open, porous texture, the one consisting of grains of sand or larger fragments of stone, the other of crystals of carbonate of lime or of the mixture of carbonates of lime and magnesia known as dolomite. In the interstices between the grains or crystals, and in other cavities and fissures, the oil is stored, sometimes under great pressure, shut in by beds of impervious clay or shale, to be discharged as a fountain or "spouter" when the protective covering is pierced by a borehole.

The bending of the originally horizontal beds into arches and troughs by lateral pressure as the cooling globe shrinks in the course of ages and the more compressible rocks are squeezed into such folds, has, in many oil-fields, the beneficial effect of collecting all the water that may have remained from the time of original formation, or have penetrated subsequently, in the troughs, and the gas (which accompanies nearly all petroleum) in the crowns of the arches, leaving the oil on the flanks of the folds, with the cushion of gas to afford the desirable pressure, and the water-seal, as in a trapped drain, to prevent escape downwards.

The arches are termed *anticlinals* (sloping oppositely), and the troughs *synclinals* (sloping together), terms of constant use in the discussion of oil-fields, in that they connote the productiveness or barrenness (in respect of oil) of successive portions of the country thus constituted. As the course of the rivers and minor streams, carving out hill and dale, is largely independent of these bendings of the rocks, effected in ages long past, an anticlinal arch may be, and often is, the floor of a valley, and a synclinal trough the ridge of a hill; the terms refer to the slope of the beds of rock, not to that of the surface, which may be quite level, or fall in a wholly different direction.

In many of the most notable oil-fields salt occurs, either as rock-salt or as strong brine, in close association with the petroleum, pointing to some obscure relation between the accumulation of salt and the original conditions under which oil is formed. It may, however, be due merely to the similarity of surroundings essential for the preservation of either substance in undiminished quantity—namely, the presence of an impervious cover to keep the oil from escaping, and the salt from the access of water. Both rock-salt and brine frequently occur with little or no trace of associated petroleum, but salt, as the more universally distributed substance, generally lingers under the cover which protects oil-deposits.

The Relation of Mud Volcanoes to Petroleum. Mud volcanoes are not infrequent accompaniments of petroleum, and by a supposed connection with true volcanic action have helped to confirm the untenable view of the purely chemical origin of oil. They are, in fact, springs of water, either pure or mineralised, cold or tepid, which, rising through apertures in fine clayey material, carry up mud in such quantity as to produce around the outlet a cone resembling that of a miniature volcano. Such cones are of all sizes, from a fraction of an inch to many yards in height, in proportion to the force of the current which has produced them. They sometimes occur with no trace of petroleum, being merely natural "artesian" wells. When occurring in oil-fields, the speed and carrying power of the current is generally enhanced by gas escaping under pressure, and the ejection of the semi-fluid mud is spasmodic, the pent-up gas, as it nears the surface, forcing a way through the last few inches in bubbles that burst with a sudden "plop," often creating a vibration perceptible for a long distance off. The spontaneous or accidental ignition of the gas of the larger cones increases the superficial resemblance to true volcanic eruptions; but, apart from the disproportion in size, there is no similarity in essential particulars between these cold-watery ejections and the molten outpourings of real volcanoes. Only where the region contains beds of soft, mud-forming material are these cones produced; the phenomenon is unknown in areas composed of more solid rocks.

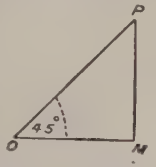
BOVERTON REDWOOD

Ratios of 45°, 30°, 60°, 90°, 180°, 0°. Relations between the Ratios of an Angle and its Complement and Supplement. Compound Angles.

RIGHT-ANGLED TRIANGLES

18. The Trigonometrical Ratios of Certain Well-Known Angles. The ratios of a few angles which are sub-multiples of two right angles can easily be found.

The Ratios of 45°. Let $\angle POM = 45°$. In one of the lines bounding the angle take any point P and draw PM $\perp$ to the other bounding line. Then, since the $\angle$s at O and M make up one and a half right angles, the remaining $\angle$ OPM must be half a right $\angle$. Hence, MP = OM = m, say. Therefore, if OP = x, we have $x^2 = m^2 + m^2$ (*Prop.* 34).



$$\therefore x = m\sqrt{2}.$$

Hence,

$$\sin 45° = \frac{MP}{OP} = \frac{m}{m\sqrt{2}} = \frac{1}{\sqrt{2}}.$$

$$\cos 45° = \frac{OM}{OP} = \frac{m}{m\sqrt{2}} = \frac{1}{\sqrt{2}}.$$

$$\tan 45° = \frac{MP}{OM} = \frac{m}{m} = 1.$$

The Ratios of 60° and 30°. Let OPQ be an equilateral Δ. Then each of its $\angle$s is one-third of 180°, *i.e.*, 60°. Draw PM $\perp$ to OQ. Then

Δ OMP = Δ QMP (*Prop.* 19).

$\therefore \angle$ OPM = $\angle$ QPM,

so that each of them is 30°. Also OM = QM, and OM is therefore half of OQ.

$\therefore$ if OM = m, we have OP = $2m$,

and $MP^2 = OP^2 - OM^2$ (*Prop.* 34)

$= 4m^2 - m^2 = 3m^2$.

Hence, $MP = m\sqrt{3}$.

$$\therefore \sin 60° = \frac{MP}{OP} = \frac{m\sqrt{3}}{2m} = \frac{\sqrt{3}}{2}.$$

$$\cos 60° = \frac{OM}{OP} = \frac{m}{2m} = \frac{1}{2}.$$

$$\tan 60° = \frac{MP}{OM} = \frac{m\sqrt{3}}{m} = \sqrt{3}.$$

Also, since $\angle$ MPO = 30°, we have

$$\sin 30° = \frac{OM}{OP} = \frac{m}{2m} = \frac{1}{2}.$$

$$\cos 30° = \frac{MP}{OP} = \frac{m\sqrt{3}}{2m} = \frac{\sqrt{3}}{2}.$$

$$\tan 30° = \frac{OM}{MP} = \frac{m}{m\sqrt{3}} = \frac{1}{\sqrt{3}}.$$

The Ratios of 0°, 90° and 180°. We have already seen, from Arts. 15, 16, 17, that

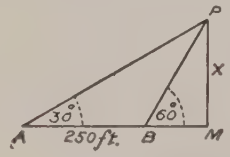
$\sin 0° = 0$, $\cos 0° = 1$, $\tan 0° = 0$.
$\sin 90° = 1$, $\cos 90° = 0$, $\tan 90° = \infty$.
$\sin 180° = 0$, $\cos 180° = -1$, $\tan 180° = 0$.

The values of the ratios thus found should be known by heart. Any required ratio is best remembered by thinking of the lengths of the sides of the triangles from which they are obtained. For example, if the value of cos 60° is required, think of the equilateral triangle, and it will easily be remembered that OM is half of OP, and therefore $\cos 60° = \frac{1}{2}$. In the same way, if sin 90° is required, think of the figure of Art. 15, and remember that as the angle approaches 90°, MP becomes nearer and nearer in length to OP, until finally $\sin 90° = \frac{OP}{OP} = 1$.

19. Solution of Right-angled Triangles. The angle which the straight line joining the observer's eye to a distant point makes with the horizontal is called the *angle of elevation* or the *angle of depression* of the point, according as the point is *above* or *below* the observer.

The Trigonometrical Ratios are, in most cases, incommensurable numbers. Their approximate values have been found for all angles, differing by 1′, from 0° to 90°. It will be seen later that this is sufficient to determine the ratios of any angle whatever. [Chambers' Mathematical Tables. 3s. 6d.]

EXAMPLE 1. The angle of elevation of the top of a tower is 30°. From a point 250 feet nearer the foot of the tower the elevation is 60°. Find the height of the tower.



Let PM represent the tower, and let A, B be the points of observation, so that

AB = 250 feet.

Let PM = x feet, BM = y feet.

Then $\frac{MP}{BM} = \tan 60°$,

and $\frac{MP}{AM} = \tan 30°$.

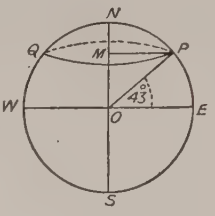
Hence, $\frac{x}{y} = \sqrt{3}$ . . . . (1)

and $\frac{x}{y + 250} = \frac{1}{\sqrt{3}}$ . . . . (2)

The solution of these two equations gives $x = 216{\cdot}5$ feet.

EXAMPLE 2. Find the distance travelled in an hour, in consequence of the earth's rotation, by a person situated in latitude 43° ; given that

cos 43° = ·73135, and that the earth's radius = 4000 miles.



Let NS be the earth's axis, and P a point in latitude 43°, *i.e.*, ∠EOP = 43°. Draw PM ⊥ to ON. Then, owing to the earth's rotation, P describes a circle about M as centre. Also

$$\frac{MP}{OP} = \cos MPO = \cos EOP = \cos 43°.$$

$$\therefore MP = OP \cos 43° = 4000 \times \cdot 73135 \text{ miles} = 2925 \cdot 4 \text{ miles.}$$

Hence, in one hour, the point P travels $\frac{1}{24}$ of the ◯ce of the ⊙ which P describes,

$$= \frac{1}{24} \times 2\pi \,.\, PM = \frac{2 \times 22 \times 2925 \cdot 4}{24 \times 7} \text{ miles} = \underline{766 \text{ miles.}}$$

20. Complement and Supplement of an Angle. We shall now prove that

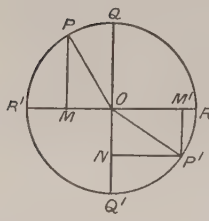
(i.) The sine of an angle = the cosine of its complement.

(ii.) The sine of an angle = the sine of its supplement.

(iii.) The cosine of an angle = − (the cosine of its supplement)

whatever the magnitude of the angle may be.

(i.) Let OP, starting from OR, trace out the angle A; and let OP′ trace out 90° − A, *i.e.*, let it first trace + 90° by turning in the positive direction up to OQ, and then turn back from OQ through the ∠QOP′, equal to − A.



Thus, in whatever quadrant OP lies, the ∠ROP which OP describes from OR is always equal to QOP′ which OP′ describes from OQ in the negative direction. Therefore P′N must always be equal to PM in magnitude, *i.e.*, OM′ = PM in magnitude. Also, by drawing figures in which OP lies in any other quadrant than the one shown, it will be seen that when P is *above* ROR′, P′ is to the *right* of QOQ′, and when P is *below* ROR′, P′ is to the left of QOQ′. Hence PM and OM′ always have the *same sign.*

∴ for all values of the ∠A we have

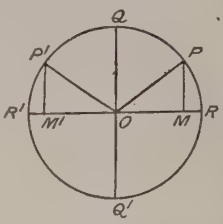
$$\frac{MP}{OP} = \frac{OM'}{OP'},$$

i.e., sin A = cos (90° − A);

or, the sine of an angle = the cosine of its complement.

(ii.) As before, let one revolving line OP trace out the ∠A, and let the other, OP′, trace out 180° − A, by turning first into the position OR′ and then back through R′OP′, equal to − A.

Hence, since the angle which OP describes from OR is always equal to the angle which OP′ describes from OR′ in the opposite direction, we have M′P′ always equal to MP in magnitude. Also P and P′ must always be both on the same side of ROR′, so that MP and M′P′ have the same sign.



$$\therefore \frac{MP}{OP} \text{ is always equal to } \frac{M'P'}{OP'},$$

i.e., sin A = sin (180° − A).

(iii.) Again, OM and OM′ are clearly always equal in magnitude, and on whichever side of QOQ′ the point P lies, the point P′ will lie on the other. Hence, OM and OM′ are always of opposite sign.

$$\therefore \frac{OM}{OP} = -\frac{OM'}{OP'},$$

i.e., cos A = − cos (180° − A).

21. In the same way, the student can easily prove for himself such formulæ as

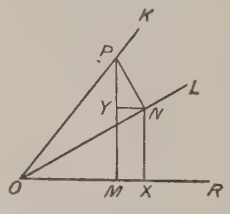
sin A = − cos (90° + A).
cos A = sin (90° + A).
sin A = − sin (180° + A).

22. Trigonometrical Ratios of Compound Angles. The "A, B" Formulæ. To prove that

sin (A + B) = sin A . cos B + cos A . sin B

and

cos (A + B) = cos A . cos B − sin A . sin B.



Let ROL be the angle A, and LOK the angle B. Then ROK is the angle (A + B). In OK, one of the arms of this angle, take any point P, and draw PM, PN ⊥ to OR, OL. Draw NX, NY ⊥ to OR, PM. Then, since ∠s PMO, PNO are right ∠s, ∴ a ⊙ on OP as diameter will pass through M and N (*Prop.* 39, *Cor.* 1). ∴ ∠s MPN, MON are in the same segment, and therefore are equal (*Prop.* 40). Hence ∠MPN = ∠A. Then,

$$\sin (A+B) = \frac{MP}{OP} = \frac{XN + YP}{OP} = \frac{XN}{OP} + \frac{YP}{OP}$$
$$= \frac{XN}{ON} \cdot \frac{ON}{OP} + \frac{YP}{PN} \cdot \frac{PN}{OP} \text{ (Art. 73, page 93)}$$
$$= \sin ROL \,.\, \cos LOK + \cos MPN \,.\, \sin LOK$$
$$= \sin A \,.\, \cos B + \cos A \,.\, \sin B.$$

Again,

$$\cos (A+B) = \frac{OM}{OP} = \frac{OX - YN}{OP} = \frac{OX}{OP} - \frac{YN}{OP}$$
$$= \frac{OX}{ON} \cdot \frac{ON}{OP} - \frac{YN}{PN} \cdot \frac{PN}{OP}$$
$$= \cos ROL \,.\, \cos LOK - \sin MPN \,.\, \sin LOK$$
$$= \cos A \,.\, \cos B - \sin A \,.\, \sin B.$$

H. J. ALLPORT

The Natural Regions, Products, and Trade of the Temperate Lands of the Far East, of the Southern Hemisphere, and of North America.

NATIONS AS TRADERS

CHINA proper with its many millions, has to be distinguished from the belt of its dependencies —Tibet, mainly an icy waste except in the south-east; Chinese Turkestan, a desert fringed with small oases, and valleys with fruit trees, cotton, etc.; Mongolia, a desert of poor steppe land, with camels and horses, and having a slightly more fertile margin; Manchuria, resembling Mongolia, in the west, but fertile and prosperous in the centre and east. Except the richer parts of Manchuria, these dependencies are of little economic importance.

The Richer Areas of Southern China. China proper consists of a hilly south and west, and a flatter north. The south has wooded hills, producing lacquer, vegetable wax, leaves for silkworms, tea; while rice, cotton, sugar are cultivated in the irrigated valleys. This region may be divided into five divisions:

(1) The plateaus of Yunnan and Kweichau, rich in gold, silver, copper, coal and iron, with outlets to Red River of Tongking, the Yangtse Kiang, and chiefly to the Si Kiang.

(2) The Si Kiang Valley, with Canton as its capital, and outlet on the delta. Near it is the British island of Hongkong, the great shipping junction of the Far East.

(3) The Eastern Highlands, with a port at the mouth of each valley, Swatau, Amoy, Fuchau (at the mouths of the eastern Min), Ningpo, and Hangchau.

(4) The Lower Yangtse Valley, which is partly in the plains, but its tributaries, the Kan, Siang, and Han, come from hilly lands rich in minerals, especially anthracite and iron, in the Siang basin. This is the valley the railway from Canton to Hankow will follow. Shanghai, on the Wusung, near the mouth of the Yangtse, is the port to which most ocean steamers come, but they can ascend past Nanking to Hankow, at the mouth of the Han, where many routes converge [see also page 2664]. Navigation is possible to Ichang, at the mouth of the gorges, where the river is very rapid, though not enough to prevent small steamers reaching beyond the gorges to Chungking. This is the port of

(5) The Red Basin of Sechwan [see page 2664], the capital of which is Chengtu, on a very fertile, irrigated plain. Coal, iron, salt, and other minerals abound.

The Rich Lands of Northern China and Manchuria. The rich lands of Northern China and Manchuria have a much colder winter than the south, the people are hardier, and even more industrious. The fertile soil, much of it loess, is irrigated and cultivated in the most careful manner, producing millets and pulses. Silk and tea are mainly confined to the south.

We may divide this district into:

(1) The plains south of the Hwang Ho, among the richest lands in China, crossed by the Grand Canal from south to north in the east, and by the railway from Hankow to Peking in the west, and from Kaifeng, where the Hwang Ho leaves the mountains, to Shanghai, near the mouth of the Yangtse.

(2) To the north-east rises the Shangtung peninsula—a hilly land with rich coalfields. Kiauchou (Japanese) is chief outlet. Chifu is the northern port and Wei-hai-wei a British station in the east of this region.

(3) In the north-west the hilly provinces of Shensi and Kansu, by which the route to the centre and west of Asia passes viâ Singan on the Wei and Langchau on the Hwang Ho. Tobacco is important in Kansu.

(4) The mountains north of the Hwang Ho in Shansi, which are among the richest mineral regions of the world, with anthracite and bituminous coal, iron and copper, which are all now being tapped and will rapidly be exploited as railways are built.

(5) The rich alluvial plains of Northern China fringing the Gulf of Pechili, with Peking to the north, and Tientsin its port.

(6) The plains and hills on East Manchuria, with much more severe winters, shorter, cooler, and drier summers; rich in beans, and capable of growing maize and wheat. The hills are wooded, and contain rich minerals, including gold, as yet little exploited. The railway runs northward from Port Arthur, by Niuchwang (the port), Mukden (the capital), to Harbin, where it joins the Russian Siberian line to Vladivostok.

Industrial Condition of China. We have seen that China is still essentially an agricultural country. It produces food for nearly 400,000,000 people, and imports very little. The needs of such a population are great, for clothing, dwellings, etc. Hence the building of houses, making of cloth, clothes, and agricultural implements are all important occupations. The manufactures, however, are still almost all domestic. An immense internal trade is carried on, but is much hampered by bad means of communication, except on the great waterways, of which the Imperial Canal and the Yangtse are the chief. The numerous customs and other tolls and the monetary system of China also hamper trade. The official coinage is confined to copper cash, of which 35 go to the penny, and most exchanges are effected by silver, which is weighed. The value of one tael weight (a Haikwan tael) fluctuates considerably: at present it equals $36\frac{5}{8}$d.

Railways in China. The era of railway construction, and the development of mining and of manufacturing by modern mills, which have just begun in China, are destined to effect an economic revolution in a much shorter time than in Europe, and of far greater importance than in Japan. The railway built from Peking to Tientsin, Taku, and Manchuria, from Peking by Paoting to Hankow, which is being extended to Canton; the line round Shangtung from Kiauchou; from Kaifeng to Shanghai; those projected up the Hwang-Wei, Yangtse Kiang, and Si Kiang; the Yunnan railway to Tongking, are among the most important which will bring the greatest cities of the interior in close touch with each other and the outer world, and will tend to develop a great trade.

Present Foreign Trade of China. The trade of China in the year 1912 was as given in the following table.

In Haikwan taels (3s. 0§d.)			
Imports	Thousands of taels	Exports.	Thousands of taels
Cotton goods ..	144,089	Silk, raw and manufactured ..	93,558
Opium	47,707	Tea	33,778
Kerosene oil ..	24,846	Beans	23,374
Sugar	23,912	Beancake	17,643
Metals of all kinds	18,242	Raw cotton	17,021
Rice	11,680	Oil (bean, ground-nut)	14,145
Fish	10,551	Hides, cow and buffalo	8,769
Coal and coke ..	8,221	Straw braid	7,644
Woollens and yarn	7,849	Skins (furs) and rugs	6,428
Matches	6,985		
Machinery	5,792		

Silk, tea, and cotton, but little produced in Europe, are among the chief exports. The cultivation of beans has assumed much importance in recent years, and during the last decade the value of the exports of beans and beancake has increased fourfold. On the other hand, the tea trade has diminished greatly since Indian and Ceylon competition came into play.

The following table shows the amounts sent to the United Kingdom from China, including Hongkong and Macao:

Year.	lb.	Value £
1890	73,743,000	2,813,000
1895	40,084,000	1,431,000
1900	21,316,000	688,000
1905	15,024,077	504,147
1910	18,914,720	650,463
1912	20,947,029	798,929

The following table shows the chief countries with which China trades, and the value of the trade done with them:

In Haikwan taels (3s. 0§d.)			
Country	Imports from	Exports to	Total
Hongkong ..	147,801	103,384	251,185
Japan and Formosa	91,017	55,262	146,279
Continental Europe (except Russia)	37,471	81,066	118,537
United Kingdom	74,856	15,900	90,756
United States..	36,198	35,050	71,248
Russian Empire	21,233	45,197	66,430
India	46,646	7,573	54,219

The Hongkong trade is with many countries. Of course, it includes more than the China trade, but an analysis of it will give some indication of how the great values entered in the trade of China under Hongkong are to be distributed.

Thus the interests of the British Empire in Chinese commerce are by far the greatest of those of any foreign Power.

Japanese Empire. The Japanese Empire for trading purposes may be divided into Japan and Formosa. The latter island is noted chiefly for camphor and tea. Gold, silver, and copper are worked.

Japan has been described on pages 2797 and 4521. Its trade may be gathered from the following table for 1912:

In yen (2s. 0½d.)			
Imports	Yen	Exports	Yen
Raw cotton ..	200,823,000	Silk, raw	150,321,000
Metals and metal manufactures	72,529,000	Silk tissues ..	34,998,000
Machines and machinery ..	31,428,000	Silk waste ..	10,543,000
Rice	31,344,000	Cotton yarns	53,680,000
Oilcake	29,609,000	Cotton manufactures	28,246,000
Wool and woollen yarn ..	24,664,000	Copper.. ..	24,923,000
Sugar	16,168,000	Coal	20,284,000
Kerosene oil ..	12,433,000	Straw plait ..	17,337,000
Sulphate of ammonia ..	12,164,000	Tea, green ..	12,849,000
Cotton goods and yarn	11,790,000	Matches	12,161,000
Soya beans ..	8,270,000	Sugar	8,477,000

It will be noticed how large a share the industrial life of Japan is playing in its trade. Raw materials, foods, ironwork, and machinery are the chief imports; and while raw silk, tea, and minerals are important exports, manufactured silk and cotton and matches are also large items in the goods sent abroad. Japan has progressed farther than China in the development of modern manufacture and commerce. Its resources are nothing like so great as those of China, but we can gain a slight idea of what may happen in China in the near future by studying the existing economic position of Japan.

Countries with which Japan Trades. The comparison of the values of imports and exports for 1912 in the table below shows how Japanese trade relations are developing.

Value in yen (2s. 0½d.)			
Country	Imports from	Exports to	Total
United States..	127,015,000	168,708,000	295,723,000
China	54,807,000	114,823,000	169,630,000
Kwantung Province ..	25,707,000	27,544,000	53,251,000
India	134,741,000	23,648,000	158,389,000
United Kingdom	116,146,000	29,791,000	145,937,000
Germany.. ..	61,075,000	13,487,000	74,562,000
France	5,421,000	43,871,000	49,292,000
Hongkong ..	881,000	28,712,000	29,593,000
Dutch Indies ..	19,063,000	4,343,000	23,406,000
Australia.. ..	12,791,000	8,628,000	21,419,000
Italy	803,000	18,412,000	19,212,000
Belgium	9,087,000	3,080,000	12,167,000
French Indo-China.. ..	10,643,000	349,000	10,992,000
Russian Empire	742,000	6,082,000	6,824,000

The United States takes tea and raw silk, and in return sends manufactured goods, raw cotton, and wheat. The United Kingdom and German trade is largely one of manufactured goods sent to Japan, from which is taken a very much smaller value of produce. The trade of France and Italy presents a very great contrast, for it is one in which raw silk from Japan to Europe plays a great part, while the exports from these countries to Japan are very small. On the other hand, Japan gets from India half of its raw cotton imports, and also much rice from Burma. The Japanese trade is thus the most complex we have yet studied.

The Three Types of Land already Studied. We have now examined three different types of countries from the commercial point of view: (1) The poor lands of the icy and arid deserts

and their margins, of little commercial value save for mineral and animal products; (2) the rich vegetations of the hot, wet forests and bordering savanas, largely self-sufficing, only here and there exploited for trade purposes, mainly where plantations have been formed under European supervision; (3) the rich lands with regular seasons—dry winters and wet summers, with large alluvial lands easily flooded and cultivated, with a long civilised history, with well-developed internal trade, hindered only by lack of easy communication, which is gradually being overcome. In India, European direction has introduced modern means of transport, but the exploitation of the country is in native hands; and while European capital has been sunk in factories, these are not all so financed, and are worked mainly by native labour.

In Japan, the European factor has been less important, and the stage of industrial evolution is beyond that of India. It is likely to be pushed farther almost entirely by the Japanese themselves. China is on the point of adopting all the more modern methods of production and communication, and it possesses probably the richest resources and the most numerous and laborious population in the world. There we may expect to find in the future the most striking economic developments not directed by European energy.

The Three Types still to be Studied. We have now to turn to those lands, almost entirely in the temperate regions, in which Europeans live and control the economic life. Three types may be studied: (1) the countries where the rural occupations are everything and industrial pursuits yield a very small part of the wealth of the country—for example, the European settlements in the southern hemisphere, in Western Canada and United States, and Asiatic Russia are of this type; (2) countries such as Eastern Canada, Central and Eastern United States, and most of Europe, except the west and centre, where industrial development is of great and growing importance, but in which the rural populations are still of great significance in their trade; and (3) such countries as Germany, Switzerland, France, Holland, Belgium, and, above all, the United Kingdom, in which the industrial development has proceeded still farther, and forms the chief source of their commercial activity.

The Main Economic Divisions of Southern Temperate Lands. We may divide the south temperate lands according to temperature and rainfall into: (1) the eastern wet regions, with hot summers and warm winters; (2) the central and northern hot arid areas; (3) the eastern regions, with warm summers and cool winters and fair rainfall, mainly in summer; (4) the western regions, with warm summers and with cool winters, during which most of the rain falls (Mediterranean type of climate); (5) and (6) the small regions of cool summers and cold winters, with rain at all seasons, little in the east, heavy in the west.

The Warm, Wet, Eastern Regions of Summer Rains in the South. Immediately south of the tropic of Capricorn lie in the east regions with warm winters and hot, wet summers where growth is checked only by drought. A considerable part of this region is well wooded, yielding fair timber. In clearings and grassy patches can be grown, in the warmer parts, some of the produce of intertropical lands, such as sugar, coffee, cotton, and rice, but the chief cereals are maize in the moister and warmer and wheat in the drier and cooler parts. Tea, pineapples, arrow-root, tobacco, oranges, lemons, and many other fruits are among the other products of this type of region, which is to be found in Southern Brazil, Uruguay, Paraguay, and eastern Argentina north of the Plate in South America; in Natal, the eastern Transvaal, and Cape Colony in South Africa; and in eastern southern Queensland and New South Wales in Australia. These roughly correspond to China and Southern Japan in their climatic conditions and economic vegetation, but the human conditions are very different, for the population is nowhere very dense, and cultivation is largely for a foreign market.

Grassland Zone between the Wet Zone and the Desert. Between the wet, forested east and the arid and desert, or almost desert, centre and west stretches a grassy area, capable of cultivation in the east and round irrigated areas in the west. While in the east the plants already named appear, in the drier irrigated areas plants of Mediterranean type, such as vines, figs, peaches, flourish. The chief wealth of these regions, however, is the live-stock, cattle in the moister and sheep and goats in the drier parts, tended by men on horseback. The mineral wealth varies greatly in different areas, and can be studied most conveniently under each country.

Hot Arid Regions. The central and western hot arid regions consist of the margin of the southern deserts, and are of little value save when irrigated. The irrigated areas are (1) in the west of Argentina, near the base of the Andes; (2) small areas in Bechuanaland and the Karroos of South Africa; and (3) in extra-tropical Southern Australia and the adjoining portions of Queensland, New South Wales, and Victoria. Here, Mediterranean fruits, maize, and lucerne (alfalfa) are the chief products. The Mildura colony of Victoria uses water pumped from the River Murray.

Outside the irrigated region the lands produce a poor scrub, which feeds small numbers of sheep, goats, and ostriches. The value of the land can roughly be judged by the rainfall. This is well shown by the following table, taken from a paper by Mr. Willis, in the "Scottish Geographical Magazine" for 1887:

District	Number of sheep per sq. mile	Mean rainfall in inches.
South Australia, dry area..	8 to 9	8 to 10
New South Wales, dry area	96	13
New South Wales	640	20
Buenos Aires	2,603	34
Irrigated land in California growing lucerne, equal to about..	12,000	60 to 100

This record shows how a series of dry years must reduce stock by lowering the power of the land to support large numbers.

The Mediterranean Type of Land. The Mediterranean type of land in the southern hemisphere has warm, dry summers, similar to those of the regions just described. It differs from them in enjoying a fair, or even heavy, rainfall in late autumn, winter, or early spring. This means that the moisture comes in the coolest part of the year, when other conditions of growth are not so favourable. The hot summers allow of the cultivation of cereals and of such Mediterranean fruits as

the grape, fig, orange, pomegranate, and olive; and here, as in Europe, the Mediterranean realm is one of corn and wine and oil. When irrigation is possible, and the supply of water in summer is sufficient, this type of region is very fruitful, as is shown by the Californian figures of the last paragraph.

This type of region is found in (1) Central Chile; (2) south-west Cape Colony; and (3) south-west of Western Australia, south of South Australia, Victoria, and the North Island of New Zealand. In the south of Australia the products are mainly wheats and fruits, with a little timber.

Sir Charles Todd has made a valuable study of the relation of rainfall to crops. Taking the mean rainfall for the winter six months, and comparing the amount with the yield of wheat in bushels per acre over a series of years, he finds the following relation: The seven best years, with an average yield of 12·43 bushels per acre, had 18·47 in. of rainfall. The five next best years, with an average yield of 10·02 bushels per acre, had a rainfall of 15·28 in. Six bad years, with an average yield of only 6·61 bushels per acre, had so small a rainfall as 13·55 in. From this we may also infer that there is a steady proportional increase in the yield of wheat per acre from the drier to the wetter parts of these lands.

One compensation possessed by the drier areas is that the quality of the produce is usually excellent, and the hard wheats of these dry areas command higher prices. [See AGRICULTURE.] Many of the trees round the margin of the dry areas yield excellent hardwood, in particular the jarrah and kauri of South-western Australia. [See BUILDING.]

The Trade of the Mediterranean Type of Lands. Most of these regions do little more than support themselves, and some do not manage to do even that, as a study of statistical tables shows. The exports are mainly minerals, wool, hides, and ostrich feathers from South Africa; timber from West Australia; wines from South Australia; and dairy produce and wines from Victoria. In examining the statistical tables, it must not be forgotten that in the case of all, except Victoria, the produce of other regions is included in the returns, as political and natural geographical boundaries by no means coincide. The trade of Chile, for instance, is mainly in nitrates from the northern deserts, and in copper, silver, and iron. These are independent of climate, and, if we exclude them, wool is the only other export of much value.

Textiles and wearing apparel, machinery, railway plant, hardware, and articles of luxury are the chief imports to these lands. The smallness of the market, and the cost and scarcity of skilled labour, are the chief hindrances to the development of local manufactures on a large scale.

Typical Trade Returns for Warm Temperate Lands. Let us next examine the trade of Uruguay and Natal as types of the eastern lands of the warm temperate zones. In this case, in order to obtain values which may be compared, we shall not quote the actual values of the statistical tables, but calculate the percentage which the value of each group of products bears to the total value. This is a valuable method of comparing statistics which the student should accustom himself to use. The values can be calculated from the total trade which is given at the top of the column.

In Uruguay, the country is only beginning to be occupied, and as yet little is broken by the plough, so that cattle-rearing is the chief occupation. In

Uruguay, 1912 Total exports, £10,156,000	Per cent.
Live animals	2·1
Animal products	80·5
Agricultural products	3·5
Other	13·9

Natal, cattle and sheep are reared on the higher slopes, but the lower warm lands near the coast are partly cleared and cultivated, mainly by Indian coolie labour. The exports to the United Kingdom in 1912 amounted to £2,725,373, of which wool formed nearly 49 per cent., hides almost 12 per cent., and maize over 2 per cent. In New South Wales very similar climatic conditions prevail. The drier interior is pastoral, the wetter east of the higher plateau cultivated with wheat, but the lower slopes round the coast grow maize, etc. Here the European alone works, and a more energetic, prosperous, and homogeneous community is growing up. In New South Wales the wealth of coal and gold is much greater than in the other lands, and is extracted by modern methods. Manufactures are rapidly developing.

The Cooler Southern Lands. The cooler southern lands, with fairly constant rains, comprise (1) South Chile, (2) Tasmania, and (3) the South Island of New Zealand, which lie in the track of the westerly storm-winds. The rain suffices for dense forests on the western slopes of the mountains, which are as yet little exploited for their timber. In some of the upper grassy valleys cattle are kept, especially in New Zealand. The mineral wealth is a very valuable asset, especially coal and gold in New Zealand. The potentially rich fisheries are not much developed.

The eastern side of these lands is much drier, and a chinook or föhn wind effect is frequently recorded. In Patagonia the country is as yet little developed, save for a few sheep-runs and gold-mines. The Canterbury Plains of New Zealand are rich in grazing ground, where many sheep are fed. The mutton is sent in refrigerating chambers to Britain, to which the wool and hides are also exported. Part of the land is cultivated with wheat. In the extreme south and in the higher lands oats are grown.

The Trade of New Zealand. The trade of these lands is small, except in the case of New Zealand, the statistics for which, however, include the produce of the warmer North Island. The export of meat and dairy produce is of recent growth, owing to the modern methods of refrigeration.

Exports from New Zealand, 1913		Imports to New Zealand, 1913	
Wool	£7,105,000	Clothing and textiles	£4,349,000
Frozen meat	3,909,000	Iron, steel goods, and machinery	4,321,900
Butter and cheese	3,769,000	Paper, books, and stationery	870,000
Gold	1,345,000	Sugar	814,000
Hides, skins, and leather	1,085,000	Oils	556,000
Grain	743,000	Alcoholic drinks	531,000
Tallow	684,000	Tobacco and cigars	488,000
Kauri gum	401,000	Fruit	433,000
Flax	376,000	Coal	365,000
Other articles	1,536,000	Tea	320,000
		Other articles	7,311,000
Total	£21,770,000	Total	£20,976,000

This is a very remarkable trade for a population of a million people. It gives a very fair idea of the economic conditions in that part of the southern hemisphere which most resembles our own island home.

Economic Divisions of Temperate North America. The present economic development of the North American lands is at very different stages. North America has been much longer settled by Europeans than has Australia, and its resources have been much more systematically and energetically exploited than those of Argentina.

The *Physical Divisions* roughly correspond with the economic ones. Broadly, they consist of (1) the mountainous west, (2) the central plains, and (3) the highlands and coastal lowlands of the east. Climatic conditions control the subdivisions of the vast central plains into tundra, forest, wheat, maize, and cotton belts, and the drier uncultivated grasslands of the higher western plains. Mineral wealth and density of population are other factors which must be taken into account in the various subdivisions, each of which has its own natural products and its characteristic economic conditions.

The Western Mountains. The high plateaus and intermont plains on the east of the western mountains are of little economic importance, except for stock-raising. The centres of settlement are (1) round such irrigated areas as those of Utah, especially round Salt Lake City; (2) in the plains at the mountain base, where the waters of the snow-fed rivers are carried over the plains; and (3) in the mining centres, which are especially numerous in Colorado, Montana, California, Southern British Columbia, and Klondike. Gold, silver, copper, and lead are the most abundant minerals.

The western valleys of the western mountains are much more favoured climatically. The temperature is equable, and the rainfall is abundant and well distributed throughout the year north of California, while in that state the winter rains are sufficient, except in the extreme south, which gradually becomes more desert-like.

South-western British Columbia, Washington, and Oregon are penetrated by straits and inlets, which permit easy sea communication. The most important of these openings are Puget Sound, with the ports of Olympia, Tacoma, and Seattle, and the straits round Vancouver Island, with Victoria on Vancouver Island, Vancouver on Burrard Inlet, and New Westminster. The last two are outports of the Fraser basin. Prince Rupert, the terminus of one of the transcontinental lines, stands on an excellent natural harbour at the mouth of the Skeena River. Farther south are Portland and Astoria, on the Columbia River, the outlet of the wheatlands of the Willamette Valley.

The lumber yielded by the forests of giant Douglas pines, the salmon of the numerous rivers, and the mineral wealth—gold, silver, lead, and copper—of the interior find an outlet through these ports. Grain from the western plains is now being brought to them in increasing quantities by the Canadian Pacific, the Canadian Northern, and the Grand Trunk Pacific railways for shipment across the Pacific. Coal is a very important export, as it is uncommon on the eastern coast of the Pacific between Puget Sound and Central Chile. Local iron ore is being smelted round Puget Sound, and shipbuilding and engineering works are being constructed. The development of this region is likely to be great and rapid.

The Wealth of California. California has a much larger area of plain than the lands farther north. Its climate is of the Mediterranean type, with winter rains. Orange, lemon, and olive groves, vineyards, peach, apricot, apple, pear, and other orchards, fields of maize, wheat, and lucerne, many of them irrigated, form its chief sources of wealth. In 1850 there were not 100,000 inhabitants in this State, which is three times the area of England. Today there are 2,500,000. The discovery of gold in 1848 attracted adventurers from all parts of America and Europe. Since then over £300,000,000 of gold has been extracted, and in 1912 over £3,900,000 was obtained. Nevertheless, it is the agricultural rather than the mineral wealth which has led to the remarkable development of California. The absence of coal has retarded the industrial development, but electricity is now generated by water power, and petroleum is much used as fuel for industrial purposes.

California possesses one of the finest harbours in the world, at the entrance to which, known as the Golden Gate, is built San Francisco, with its 420,000 inhabitants. This is the chief port in the eastern Pacific, with steamship lines for all parts.

The Central Plains North of the Missouri and Ohio. Furs and lumber are the economic products of the tundra and forests. The latter industry is very important round the Great Lakes, the St. Lawrence and its tributaries, where lumber is sawn and made into joiners' work and wood-pulp for exportation. The grasslands and the forest clearings are cultivated with wheat, and towards the south with maize. In the drier west stock is raised on the natural "buffalo" grass. In the agricultural area hogs and cattle are fattened on maize and the offal from the flour-mills. Round the Great Lakes are rich supplies of iron and copper ore, and farther south are vast coalfields which supply power for many growing industrial centres. The St. Lawrence and the Great Lakes and the Mohawk-Hudson valley are the chief natural routes from the east to this area, which has other outlets across the Appalachians and down the Mississippi. Three aspects of the economic life of this area deserve more detailed study: (1) The Canadian conditions; (2) the agricultural belt of the United States, and the industrial development consequent on its needs, and (3) the metallurgic activities of the eastern portion and the mining on which it depends.

Canadian Commerce.—Exports. Let us once more turn to statistical tables, which will give us a clear conception of the most important aspects of Canadian commerce, derived as it is mainly from this region. The value of the exports from Canada in thousands of dollars ($1000=£206) for the three years 1903, 1912-13, 1913-14 is as in the following table.

Exports from Canada.	1903	1912-13	1913-14
Mining products	31,062	57,442	59,039
Fishery products	11,800	16,336	20,623
Forest products	5,300	43,255	42,792
Animals and their products	69,818	44,784	53,349
Agricultural products	44,624	150,145	198,220
Manufactures	51,714	43,692	57,443
Miscellaneous	84	97	121
Total	214,402	355,751	431,587

The 1913–14 figures may be further analysed as follows: Gold quartz accounted for $13,320,000, copper ore for $9,489,000, coal for $4,040,000, and

silver ore for $20,971,000. Of fresh and salt water animals and fish, lobsters were the most important, accounting for $3,691,000; codfish was valued at nearly $4,706,000, and salmon at $7,455,000. Of forest produce, unmanufactured timber was worth $42,743,000, and wood-pulp $6,364,000. Cattle were the most important animals, valued at $7,906,000. Hides and skins accounted for $9,262,000, leather for $3,213,000, and furs for $5,667,000. In the dairy industries, bacon was worth $3,763,000, butter nearly $309,000, and cheese (the most valuable of all) brought in over $18,808,000. Of the produce of the fields, wheat is the most important, accounting for $117,719,000, and for nearly $20,581,000 more in the form of flour. Oats are worth $13,379,000, while fruits amount to over $4,585,000. Of the manufactures, agricultural implements amount to $7,219,000, and iron, steel, and machinery to $4,155,000.

The minerals are from the western mountains and the maritime provinces. Salmon is obtained mostly from the western, the other fish from the eastern, waters. Of the other products from the regions more particularly under consideration, wheat is obtained from the central plains, with Winnipeg as its collecting and distributing centre. Dairy produce and cheese are almost exclusively from Ontario and Quebec, and fruits from the Niagara peninsula and Nova Scotia.

All these exports are carried mainly across the Atlantic. The St. Lawrence forms the chief outlet for this trade in summer. In winter, when it is frozen, Halifax, St. John, N.B., and the United States ports have to be used. In 1912–13 Montreal shipped over $85,000,000 worth; Quebec, $8,500,000; St. John, N.B., $25,500,000; and Halifax, $15,000,000, while Vancouver, on the Pacific coast, handled $11,000,000 worth. During the last five years 38 per cent. of the exports were to the United States, and over 48 per cent. to the United Kingdom. The West Indies, the next market on the list, took only 2 per cent.

Imports to Canada. The following table shows the nature of the imports. Over 65 per cent. of the revenue of Canada is derived from its Customs duties. The value is again given in thousands of dollars ($1000=£206):

Nature of Imports to Canada	1903	1910–1911	1912–1913
Agricultural produce ..	18,464	35,304	46,655
Animals and their produce	15,577	23,258	41,088
Fisheries produce	1,403	1,995	2,674
Forest produce	5,116	12,873	20,138
Manufactures	150,590	310,514	465,198
Mineral produce	20,317	44,020	65,820
Miscellaneous	22,318	33,985	33,940
Total	233,785	461,949	675,513

In 1913–14 the imports amounted to $650,746,000, of which manufactures formed the largest proportion. Of the manufactured articles, iron and steel are by far the most important, amounting in 1913–14 to over $119,000,000. A very large proportion comes from the United States, as do the imports of coal and coke, which are valued at $52,000,000. Cotton manufactures, which are next on the list ($37,000,000), enter from Great Britain under the preferential tariff, as do woollen goods, worth $31,000,000. Cotton-wool and waste ($8,000,000), free of duty, and tobacco ($7,000,000), also mainly duty-free, enter for the manufacturing centres of Montreal, Western Quebec, and the Lake peninsula. Sugar (over $17,000,000) and fruits (over $17,000,000) come largely from the West Indies. Wood manufactures, carriages, drugs and chemicals, oils, manufactures of silk, of jute and hemp, and of gutta-percha are important items in the import trade. The United States does more than any other country to supply Canada's needs, to the extent of 62 per cent. on the average of the last five years. The United Kingdom supplies less than 23 per cent., and Germany, France, and the West Indies come next in order.

The ports by which these imports enter are of interest. Montreal still heads the list with nearly $156,000,000; but Toronto comes next with over $121,000,000. Quebec has nearly $15,000,000, Halifax over $12,000,000, Ottawa slightly over, and St. John, N.B., a little under, $10,000,000, while Vancouver has $44,000,000.

The Central United States. As in Canada, the west of the United States is a ranching country, raising cattle and sheep. East of 100° W., the rainfall is sufficient for agriculture. Wheat is the staple crop in the north, and maize in the south. Most wheat is grown in the Red River valley and the Dakotas, but it is cultivated even south of the Ohio mouth. Much of the crop is forwarded to the Lake ports (Duluth, Superior, Chicago, etc.) and sent by the Great Lakes to Buffalo, where most of it is put on the rail for New York. Part of it goes by rail the whole way to the eastern and Gulf ports. An increasing amount is sent by rail across the Rocky Mountains to Puget Sound. The cost of transport has been extraordinarily diminished in America. To lessen its ratio to the value of the freight a large proportion of wheat is milled into the more valuable and compact form of flour. Minneapolis, where the Falls of St. Anthony supply water power, Superior, Duluth, Kansas City, and many cities farther east, are important milling centres.

Similar considerations of economy lead in the maize belt to the fattening of cattle and hogs on the crop raised. The stock and the cattle and sheep from the ranches are slaughtered and sent east as "chilled meat" in refrigerated trucks. Enormous quantities are "packed" or canned. The hides are made into leather. The wool and hair, bones, sinews, and even the blood and offal, are utilised in various ways. The mutton is sent mainly to the Eastern States, but much beef is exported. The chief meat-packing cities are Omaha and Kansas City on the Missouri, and Chicago. Formerly Cincinnati was the "Porkopolis" of the United States, and St. Louis rivalled Chicago. As settlers moved westwards new meat-cities grew up, but the old ones still retain a fair trade.

These regions need railway plant of all kinds, agricultural implements, and the clothing, luxuries, and other requirements of a population which is not, like many of the Old World peoples, self-supporting. The railway has been in many cases the precursor of settlement, for without it the settler could neither procure supplies nor send his produce to market.

The Industrial Region East of the Mississippi. A generation or so ago the now busy and populous region east of the Mississippi preserved the same characteristics as the region just described. Now all is changed. Coal is widely distributed and mined, and used at all the great and growing cities for their numerous and varied manufactures. Between Western Pennsylvania and Illinois are many oil and natural gas-wells,

which supply a valuable fuel. The petroleum is conveyed in pipes to Chicago, Pittsburg, Cleveland, Buffalo, New York, Philadelphia, Baltimore, and other cities. Iron ore and limestone occur in the Western Pennsylvania coal, oil, and gas field, with the result that this region has become one of the leading steel-making centres of the world. The local ore no longer suffices. Fortunately, iron ore is abundant round Lake Superior, whence it is shipped in giant "whale-back" steamers to Chicago and the ports on the southern shores of Lake Erie to be smelted. Much is carried by rail from Africa. Since their emancipation these negroes have still remained the chief cultivators of the ground. Nearly three-quarters of the raw cotton of the world is grown in this area. Most of it is shipped to Europe (half to England) and New England from Galveston, New Orleans, Mobile, Pensacola, Savannah, Charleston, Wilmington, and even Baltimore. The sugar and rice of the south are not much exported. The tobacco of the northern margin of this belt is exported, the great markets being Richmond (Virginia), east, and Louisville (Kentucky) west of the Appalachians.

THE BEGINNING OF THE INDUSTRIAL GREATNESS OF CHINA: A VIEW OF PART OF THE VAST HUNYANG IRON AND STEEL WORKS AT HANKOW

China has enormous resources of both coal and iron. Seventy miles from Hankow there exists one of the richest deposits of iron ore in the world, the amount on the surface being estimated at five hundred million tons.

to Pittsburg, the greatest iron and steel city in the world. Here, again, remarkably low rates of carriage have led to an extraordinary economic expansion. The ore is carried to the fuel because the fuel is near markets for the finished products.

The Central and Southern Atlantic Plains. The Central Plain south of the Ohio and the Southern Atlantic Plain is a hot region where cotton is the most important crop. Tobacco is grown in the north and sugar in the south. Throughout this region the labour problem, which is a difficulty in many hot lands, was formerly overcome by the importation of slaves, mainly

The Southern Appalachian coal and iron field has only recently been adequately exploited. Steel and iron are made round Birmingham (Alabama). A remarkable feature is the rapid development of the cotton manufacture of Atlanta and other manufacturing centres of the other States, but unhappily child labour is largely used to cheapen production and supply the necessary labour.

The New England Manufacturing Area One of the earliest English settlements in North America was on what is now known as the New England coast. Gradually the pioneers made their way inland across a rather poor highland

into the parallel fertile valleys. These diminished in agricultural importance with the opening up of the prairies in the west. The irregular shores of New England afford good harbours, but fishing and the building of ships with timber from the forested hills have both declined. The result is that New England has specialised in manufactures, a development rendered easier by the abundance of water power. With improved facilities of transport, coal is brought from Pennsylvania by sea and rail, while cotton is imported from the south and wool from the east oversea. Leather, boots, clothing, ironmongery, clocks, watches, and many other articles are manufactured.

Economically there is a marked tendency for the more skilled occupations to expand while those employing less trained labour pass elsewhere. The manufacture of coarser cottons has thus been transferred to the South Appalachians. The chief New England cotton centres are Lawrence, Lowell, and Manchester on the Merrimac River, Augusta and Waterville on the Kennebec, and other cities on the New England rivers, not far from the coast. Fall River, in Rhode Island, is also a seaport, and the consequent reduction in transport charges has made it the largest of all. Woollen factories are more widely distributed. Lawrence and Lowell are busy centres. Carpet-making is important at Lowell and Hartford. Lynn, Brockton, Haverhill, and other towns make boots and shoes and Waterbury watches. Worcester is a great engineering centre. There are many towns with varied manufactures, especially of ready-made clothing. Of these industrial centres Boston is the chief port, but it is cut off from the great western industrial and agricultural area by the Berkshire and other highlands of Western New England.

The Central Eastern Industrial Area. The central eastern industrial and commercial area is very important. The great inlets which penetrate to the "fall line" make admirable waterways to the manufacturing centres, which are grouped round the anthracite fields of Eastern Pennsylvania. Many large towns are noted for special industries, but in this area engineering, especially in Philadelphia and New York, is even more important than textile manufactures. Philadelphia is the chief locomotive and shipbuilding centre in America. Locomotives are also constructed at Paterson, near New York, Scranton, Richmond, and other centres. Ready-made clothing is an important industry in New York, Philadelphia, Baltimore, and other cities in the States.

The central eastern ports are Baltimore, Philadelphia, and New York, which have already been described on page 3165.

Exports and Imports of the United States. The exports of the United States are gradually altering in relative importance. Manufactured articles form a steadily increasing proportion of the exports. The figures for 1912–13 are, in round numbers:

Cotton, unmanufactured	$547,000,000
Iron and steel and manufactures thereof	304,000,000
Breadstuffs	211,000,000
Meat and dairy products	153,000,000
Copper and manufactures thereof	$143,000,000
Mineral oils	137,000,000
Wood and manufactures thereof	115,000,000
Coal	65,000,000
Leather and manufactures thereof	63,000,000
Tobacco and manufactures thereof	55,000,000
Carriages, vehicles, etc.	54,000,000
Cotton manufactures	53,000,000

The chief imports for 1912–13 are, in round numbers:

Coffee	$118,000,000
Hides and skins	117,000,000
Sugar	103,000,000
Chemicals, drugs, and dyes	99,000,000
Indiarubber	97,000,000
Raw silk	84,000,000
Fibres, vegetable and textile grasses, manufactures of	76,000,000
Cotton manufactures	66,000,000
Wood and manufactures of	61,000,000
Tin, in bars, blocks, etc.	53,000,000

Of the exports, 32 per cent. consist of finished manufactured articles, and an additional 17 per cent. of articles partly manufactured; 30 per cent. are raw materials for manufacture, and the remainder of the exports (21 per cent.) consist of foodstuffs, either raw or prepared. Owing to the increased home demand, the quantity of agricultural produce, especially wheat, available for export is gradually diminishing. Of the imports, 33 per cent. consist of raw materials for manufacture, and 20 per cent. of manufactured articles.

Countries with which the United States Trades. The United Kingdom is by far the best customer of the United States, and supplies most of its imports. Germany comes second in both capacities. The totals for the chief countries for 1912-13 are given in thousands of dollars in the subjoined table, which students can examine in greater detail.

Country	Exports to	Imports from	Total Trade
United Kingdom	597,150	295,564	892,714
Canada	420,148	121,723	541,871
Germany	331,684	188,963	520,647
France	146,100	136,877	282,977
Netherlands	125,909	38,180	164,089
Brazil	42,638	120,155	162,793
Japan	57,741	91,633	149,374
Mexico	54,571	77,543	132,114
India	15,108	116,178	131,286
Italy	76,285	54,107	130,392

The United States is a vast country, nearly as large as the whole of Europe, with a greater variety of climate and products, and with even greater mineral wealth. Consequently, we must compare the vast area for internal trade which exists in the United States with that of Europe. The same fact should be borne in mind when we compare the foreign trade of the United States with that of our own country or of any other single country in Europe. Within a very short time the United States' foreign trade ought far to surpass that of any other country. This, however, need give us no cause for patriotic misgivings. The world's wealth of purchasing is not a fixed and exhaustible quantity, but one that is ever increasing; and we may view the success of other countries without alarm so long as our trade shows no signs of shrinkage.

A. J. AND F. D. HERBERTSON

FAMOUS EXAMPLES OF ART METAL WORK

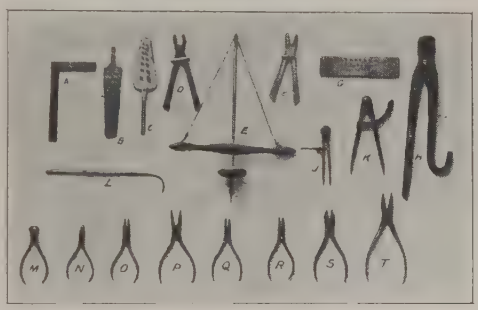
PORTION OF ENGLISH WROUGHT-IRON SCREEN OF 1695 AT HAMPTON COURT PALACE

BRONZE GATES, BY ANTONIO GAI, IN FRONT OF THE LOGGIA OF THE CAMPANILE, VENICE

Considerations of Art in the Treatment of Metals. Embossing and Chasing. Casting, Spinning, and Turning. Engraving. Iron and Steel Work. Enamelling.

ART WORK IN METAL

THE work of the hand is the first and last consideration in the expression of art in metal-work of any kind. When such is adequately given, the result is always sufficient to justify its existence. There is no art in any piece of work which does not possess the qualities obtained by hand work. To demonstrate this it is only necessary to try to think of a machine producing a work of art. Such a thing is inconceivable, inasmuch as all art is the expression of man's thoughts and feelings. The hand well trained alone can achieve that. One of the most lamentable things is to witness the painful effort of a worker to imitate the result obtained by the use of machinery. In the ordinary workshop this seems to be the great desideratum—the essential. That it is necessary, then, to make art objects with the hands implies also that the design must be such as can best be expressed by hand work. Hence it follows that all designs should be made by one who not only knows the methods employed in the craft, but has also either practised it or is working in it. Not only so, but he must also have the keenest sympathy and enthusiasm for it. The designer and craftsman should be one and the same person, until he knows the craft so thoroughly that he can guide the work while being made by other hands than his own. For it is the artist who, by working continually in a chosen material, best understands its capabilities and what beauties can be wrested from it, as well as its limitations and suitable application. It is this true appreciation of the qualities of a particular metal which calls forth the highest design. To make the point clearer, attention is called to the frequent misapplication of metal-work, shown by the reproductions of woodwork, stone carving and plaster moulding, in wrought metal. This proceeds from a mistaken view of the use of metals, or the lack of either the knowledge of its capabilities or of invention and sympathy on the part of the designer. Not only is this true of the material, but also of the process, as in the case of wrought and cast work, where the difference should be felt and understood throughout the whole design.



1. VARIOUS TOOLS

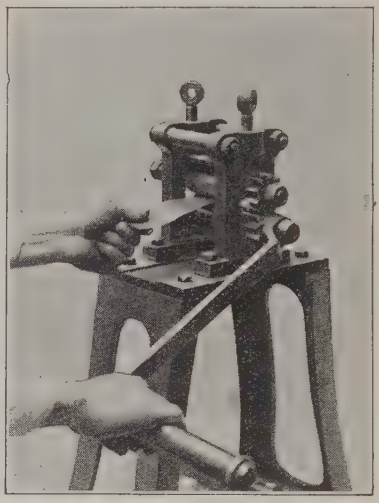
A. Steel straightedge *B* and *C*. Screw-plates *D* and *F*. Slide pliers *E*. Drill and stock *G*. Draw-plate *H*. Draw-tongs *J*. Spring dividers *K*. Wing compasses *L*. Mouth blowpipe *M*. Nippers *N* to *T*. Varieties of pliers

Study and Practice. The study and practice of the craft should be carried on at the same time as the study of design, either upon paper or in wax. They should not be pursued separately—that is, at different periods, one taken up for several years, and then the other—lest they both suffer. For by realising and embodying the idea or conception in metal, the mind gradually becomes accustomed to seeing clearly the design being made from start to finish in all its parts. In fact, so clearly is it perceived, that after a time the conception will present itself as vividly before the mind's eye as though it existed in actual metal before it. It is one of the most difficult mental problems to design or draw anything without having a clear presentiment or vision of the object. The usual method is to grope about over a piece of paper until something suggests itself from the number of lines sketched in, which, when it comes to be made, is found to look quite different from the drawing. Therefore it is best to advocate as a system of training the development of a constructive imagination, by the continual practice of both the design and the craft. They should never be regarded in the light of separate things. It is this unnatural divorce between craft and design which has been one of the chief causes of most of the deplorable work of the beginning and middle of the last century and much of the work of to-day. And one can only look forward to the time when they shall be united once more. Another deterrent in the production of art of a lofty aim is the lack of interest in fine art work of to-day displayed by the purchasing public. We are told that attention and devotion to ancient art is caused by the absence of really fine work to-day. At least, then, let us remove this cause.

Simplest Art is the Highest Art. Now, for reference only, the best study is to be found amongst the old work of the early periods of any civilisation. For specimens of goldsmithing and jewellery, those amongst the ancient Irish, Celtic, Greek, and what is left of Egyptian, Coptic and Scandinavian collections are to be sought; for wrought iron, British, German, Flemish, and French; for pewter, Dutch, English, and German; for silver, English, French, German, and Dutch; for enamels, French, German, and Italian. The earlier the date—in any civilisation of any piece of art work—the more generally does it imply the possession of those qualities which go to produce the finest art, such as simplicity, directness, purity of *motif*, restraint, virile strength, imagination and severity, together with the utmost perfection of handling and colour as seen in its best in the Irish jewellery. The later the period the more significant of redundance, femininity, extravagance, pretentiousness, poverty, and often impurity of *motif*—of conception, lack of breadth, simplicity, and the qualities possessed in earlier periods; such art work, so-called, has nothing but complete banality in all

its parts, as seen at its worst in the French and Flemish Rococo, and periods under the influence of the Jesuit Bourbons. The decadent periods are usually the precursors of social and artistic revolution. followed by a reaction affecting severity and simplicity, as seen in the Empire style of France and the Adams style in England.

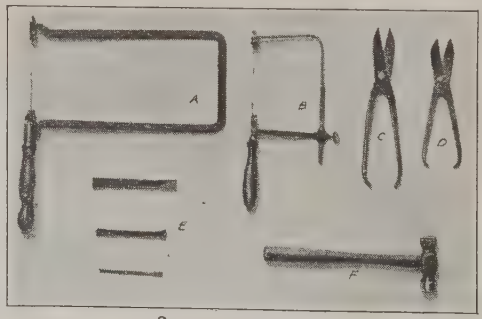
The True Value of Early Examples. The study of these styles or of any other should be for the sole purpose of understanding from them the expression of given forms and contours, contrasts and arrangements of line and mass not merely for the sake of the continuation and repetition of these styles, for no artist should be content to repeat the forms of expression used by men who have had their day and ceased to be. That is the wrong application of such study, and it is a sign of the times of how little is understood by the world of art when it is quite happy in seeing an endless purview of dead styles, thus causing on the part of artists and designers all effort of a sincere and original kind to be regarded as bad. This is prejudice and indifference, that kills or must be killed.



2. ROLLING METAL IN HAND MILL

This is a grotesque inversion of the idea held with regard to science and literature, and of what is considered advantageous and progressive for them. For in science the reverse holds good. In literature it would be considered as unworthy for authors to imitate the idioms, phraseology, and words as to repeat the ideas of writers in past times.

Study of Nature. Then, while studying ancient art, give more thought and reflection to Nature. Study her in all her varying moods, in her infinitely beautiful means of expression, from the smallest herb and flowering plant to the great trees, the movement expressed in their great limbs under the strain and stress of the storm, and the movement of the waters of the sea, and again the cloud masses. Then consider the lines expressive of calmness and strength in the steadfast hills; but study her most closely, intimately, in the forms and movements of animal life, and of the human figure. Do not study with the intention of copying, so much as to analyse what feeling or intention can be best expressed by adopting similar lines, masses, contours, whether of strength, beauty, grace, grandeur, gentleness; ascertain how she builds her forms and clothes them.



3. CUTTING TOOLS
A. Large frame and fret-saw *B*. Smaller ditto
C and *D*. Shears *E*. Chisels *F*. Hammer

Design. Referring in the most general terms to the broadest principles of design, it is necessary to bear in mind only that the straight line is the most beautiful of all lines, and that any deviation from it is less beautiful. Thus the curve, which is nearest the straight line, is the one that appeals to us most, as in early Egyptian, Greek, Celtic, and Saracenic art. So also in relief, flat surfaces are preferable to rounded, just as in the highest Greek form it is the flat planes and surfaces with the least curvature of parts which attain to that perfection of strength, beauty, and virility which one sees embodied there. Now, one of the great qualities in design is that described as "largeness of feeling." By analysis of most of those works which are generally conceded to be the finest, it will be noticed that this quality is maintained by simplicity, directness and singleness of conception, and scale in execution. It will be observed that there is a total absence of short curves, of violent light and shade, of prominent detail, and of confusion of parts, multiplicity of ideas, or complexity of aim. Detail, enrichment of surface, or ornament, elaboration of plan, were used so as to emphasise the beauty of the bare spaces, and in so doing these gave great preciousness to the enrichment. For it is apparent that straight lines, flat planes, simplicity of plan stand for and represent the great abstract quality *repose*, and therefore continuity, which implies infinity. In a similar way a curved line or surface repeated a great number of times suggests the same quality in a minor degree. If follows that all masses or curves, such as waves of the sea, or elaborations of whatever kind, carried on in a straight direction, repeated over a surface, represent the same idea. The trunk of a fir-tree, as straight as a column, or the slight curving growth of a chestnut, both indicate repose, because of the straightness of the direction of their growth. Contrast this with the gnarled oak. How eloquent it is of storms encountered and fought with! So that the broad principle is that continuity and simplicity, as represented by flatness of surface or straightness of direction, signify repose, infinity, and in the greatest work the sublime; and the contorted, twisted, intersecting, are emblematic of change. The smaller the curve and the more abrupt the angle of contour, the more rapid movement do they imply, and so on, in a descending scale.

Applying the Principles of Design. These general outlines the student must try to fill in for himself, and in doing so he will doubtless encounter many obstacles. But he will find ultimately that they are true. He will meet many things in nature, apart from the disputations of his fellows, which seem to say otherwise. It is important that

the student should understand the means of conveying his intention. If he wish to attempt to walk along the high and lonely road towards the lofty planes of the beautiful, he will find it necessary to exercise great restraint even while exercising his imagination to the full. He will find that the beautiful implies the abiding sense of continuity. Life itself is transitory in the individual, but continuous in the race. Reflect upon this, for it is generally understood that variety, change, and contrast are the most beautiful qualities in art, whereas the contrary is proved to be the case in all the greatest monuments of antiquity and the present day. Then, if in the greatest, surely in the humblest work also. To take but two of the best known examples of different styles, the Parthenon and the interior of Westminster Abbey. In the former the whole composition is made up of straight lines and flat planes. The interior at Westminster is similar in this respect where the shafts are simply a mass of upright columns tied together, which in their sustained length, gently and slowly curving at the top into arches, give the almost extreme perfection of the expression of aspiration in repose.

4. DRILLING WITH A DRILL IN A STOCK

Harmony in Art Work. Yet it is also one of the axioms of design that suitability of purpose should govern a building, and consequently the governing facts in its decoration should be that it is in harmony with that purpose. So that edifices of a serious great motive and intention shall be decorated only with suitable appropriate ornaments, just as much as those of a lighter character. These remarks seem to be so obviously true, and therefore unnecessary, yet how often does one see our theatres dull and heavy, our drawing-rooms uninspiring, our churches full of unsuitable crudities displaying the utmost poverty of imagination and inappropriateness of form and colour. All there is consists of only such ornaments as can be stolen from some historical document concerning the art of a period and religion of a character totally different from the present one; in fact, everything save that which should be in such places of worship, praise and prayer. The subject of design as applied to the right use of curves, accent, harmony, and other qualities, and the appropriate treatment of materials, are discussed in the article on Design.

5. SOLDERING WITH BLOWPIPE AND FOOT BELLOWS

Metals. The number of known metals is considerable, there being forty-five in all. The majority of these are suitable in one form or another for art metal work, although very few are employed to any great extent.

The following comparisons show the different properties and characters of metals, which are here arranged in the order of their suitability to the purpose named above them.

MALLEABILITY. Gold, silver, copper, tin, lead, brass, zinc, platinum, iron, aluminium.

DUCTILITY. Platinum, silver, iron, copper, gold, brass, aluminium, zinc, tin, lead.

FUSIBILITY. Aluminium, tin, lead, zinc, brass, bronze, silver, copper, gold, iron, platinum.

ALLOYS. Copper alloyed with zinc gives brass, copper alloyed with tin gives bronze, silver alloyed with copper gives standard silver, gold alloyed with silver and copper gives the different carats of gold.

The junction of metals is attained by various means as follows:

In gold work the parts are joined by solder made of gold and silver or gold, silver, and copper melted together in proportions according to the carat of the gold.

In silver work a solder is also used made of silver and copper.

In copper work spelter made of copper and zinc, and a solder of copper and silver in much the same proportion.

In brass work spelter and a common silver solder, made of brass and silver is used.

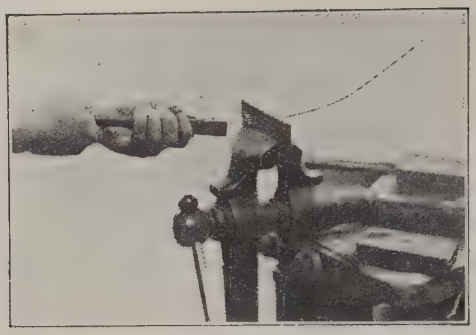
In iron work by welding and brazing.

In pewter, lead and tin and aluminium by fusion, and by pewter solder.

Nickel by silver solder.

All metals can be screwed, tied or riveted together.

That metals differ very widely in many respects, and that they are hard and soft and of different colour, is common knowledge. These differences can be modified considerably in most cases, which enables the worker to produce many things which otherwise would be impossible. Steel is the hardest metal. It is made from iron by introducing carbon into it while in a molten condition. But it can be made into a soft, pliable, or rigid metal according to the different properties of carbon and iron, or as brittle as glass by different applications of heat and methods of cooling afterwards. Possessing this remarkable quality it has become the most useful of all metals. Copper is the next most useful metal. Tin, lead, and zinc are largely used when mixed with other metals or applied to them. Gold and silver, besides being the most beautiful, are among the rarest metals found in the earth, and this prohibits them from being more generally employed. Other metals such as cadmium, vanadium,



6. DRAWING WIRE

palladium, nickel, mercury are untarnishable metals of a silvery quality, which are usually applied to other metals for their reflective qualities, and for the protection of others the surfaces of which would otherwise rapidly deteriorate through chemical change caused by the atmosphere.

Processes in Metal-work. In the manipulation of all metals, the same processes are employed. The main difference in treatment lies in the size of work and the quality of handling. In the precious metals, gold, silver, and platinum, the handling should be kept fine and delicate according to the size and preciousness of the material—consequently the tools [1] are small and minute, whereas in making wrought iron they are, comparatively speaking, of enormous size. The hammers and punches, the drills and stocks, the stakes, mandrels and files are naturally regulated by the size of the work. So that here we shall describe the processes in detail common to all, in reading which it will be necessary for the student only to think of his material—either copper, iron, steel, gold or silver—to understand the matter rightly. All metals can now be procured in the sheet, bar, rod, or wire of almost any dimensions. Most of these are prepared by machinery to-day, and are as perfect as is necessary for all intents and purposes. The method employed in making sheet metals is as follows :

An ingot of the metal is cast measuring and weighing the proportionate amount to the sheet required. This is hammered into a flat piece, and after annealing it is placed between the steel rollers of the rolling or flatting mills [2], and then rolled, the size being gradually reduced by the tightening of the rollers to the gauge decided upon.

The gauge is a flat piece of steel about $\frac{1}{8}$ in. thick, and having along both its edges a series of slots with a number marked below each for the purpose of quotations and reference, as seen in the illustration. There are two gauges in general use in this country, which causes great inconvenience owing to the frequent misunderstanding of the numbers quoted, so that it is highly necessary to state the kind of gauge which is referred to in an order. The names of these gauges are "Metal Gauge" and "Birmingham Wire Gauge."

7. "BLOCKING OUT" A BOWL

Sheet Metal. "Sheet" iron, copper, brass, gilding metal, are sold in sheets of varying dimensions, the most general size being about 4 ft. by 2 ft. The limit is according to the size of the rolling mills. To Mr. Sherard Cowper Coles we are indebted for an improvement in this limitation of size as regards copper inasmuch as by electrically depositing copper upon a cylinder a much greater size is reached and greater saving in the cost of production.

Annealing. Annealing is a word used to denote the process by which a metal is softened to its normal state after it becomes hard through bending, torsion, hammering, rolling, or through any process which involves the pressure of the particles of metal upon each other. Fine gold, fine silver, lead and tin do not become hard by hammering, but alloyed gold and silver, nevertheless, become hard enough to require annealing. Each metal requiring annealing is subject to the following treatment. It is first made hot, and kept hot equally all over, if possible, for a few minutes, and then allowed to cool gradually. In the case of steel it is necessary to arrange so that it cools very slowly, protecting it from the air while so doing. Other metals do not require so much care, but brass, low carat gold and standard silver should never be cooled rapidly by plunging into cold water, as may be done with copper.

Cutting. For all the soft metals—gold, silver, copper, tin, lead, nickel, iron and brass—if of an ordinary thickness a pair of steel shears or cutting pliers, or a metal-saw or fret-saw [3] is used for cutting. Shears can be bought either curved or straight, and suitable for cutting with the left hand or right. Metal-saws of almost any size can also be readily obtained. For cutting hard metals or thick metals, steel chisels are used. The angle at which these are sharpened is a very wide one, in order to keep the strength well down to its cutting edge, and they are tempered to a straw colour. Fret-sawing is done by first drilling holes in the various parts to be cut out, and then passing the saw through, fixing it firmly in the frame, and sawing in the usual manner, keeping the saw at right angles to the sheet of metal.

Tempering. Although tempering belongs particularly to one metal only, yet, as it has to do entirely with tools, we must describe it here. The first thing in making a steel tool is to soften the steel by heating it to a pale red and allowing it to cool very gradually, and then, when cold, to file it into the desired shape if a straight tool, such as a chisel, and if for a curved tool, by bending it while red hot. Then, to temper it, the steel is hardened by heating it again to a pale, red colour and plunging it into cold water. After this, one side is cleaned by emery cloth, and then a blowpipe flame is applied to within an inch or half an inch, as the case may be, until this part appears blue and the tip an orange colour. The moment this is reached the tool is plunged once more into cold water to arrest its further progress of softening. Now the tool is hard where it is straw colour, but not brittle, and tough where it is blue, yet not soft enough to bend while being struck. Swords are tempered in the same way.

Drilling. In order to fix some parts of metal work together it frequently happens that they cannot be brazed, soldered, or welded together. In such cases the parts are held together by rivets or screws. Before any of these operations can be performed the separate pieces must be drilled [**4**]. Now, drilling is done either by means of a drill rotated by a bow, or fixed in a stock, or by a chuck placed in a lathe. A complete set of drills can be obtained from any silver or copper warehouse. The whole operation of drilling is a very simple one, as it entails merely the fixing of the drill securely into the breastplate if a bow is used, or into the stock or chuck, and causing it to revolve rapidly upon a given point. Drilling is aided by the addition of a little oil placed at the point of the drill for soft metals, and of soapy water for steel

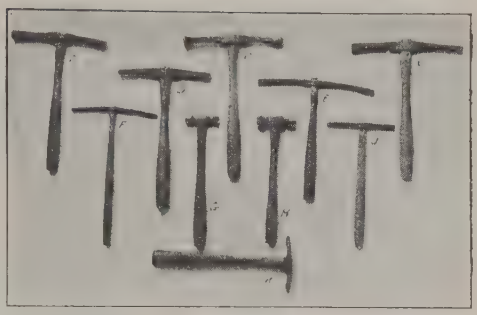
Soldering and Brazing. Soldering and brazing are identical in their process, which is performed as follows: The two surfaces are cleaned thoroughly either by filing or scraping or rubbing with emery paper, and when these parts are thoroughly clean the pieces of the metal are bound together with wire or held in position by clamps, or are fixed in fireclay or upon other stouter pieces of metal, and then the parts to be soldered or brazed are painted with borax dissolved in water, and the

9. PLANISHING A SILVER BOWL ON A STEEL-FACED STAKE

solder is cut into small pieces, which are placed along the boraxed parts. When this has been done the whole is subjected to a red heat produced by a gas blowpipe [**5**]. In the case of small work, such as jewellery, a mouth blowpipe is preferable; but for large work a large blowpipe with a foot bellows is used.

Wire-drawing. The process of wire-drawing [**6**] is performed by means of pulling the wire through a regular series of holes pierced in a hard steel-plate by tongs. This plate is called a *draw-plate* and the tongs *draw-tongs*. As the metal wire becomes very hard and brittle in the process of drawing, it is necessary to anneal it repeatedly and to use a little oil when passing it through the plate.

Hammering. The methods employed are practically the same as have existed from antiquity. They consist of first raising the metal from the back and then finishing it from the front. The softer metals only are used for the purpose of making objects such as cups, tazzas, bowls, vases and other articles of a similar form. The tools employed are those of the most primitive yet effectual character. They are hammers of various kinds [**8**], as shown in the illustration, the size of which is naturally governed by the size of the object. The long-headed hammers are used for raising and drawing in the



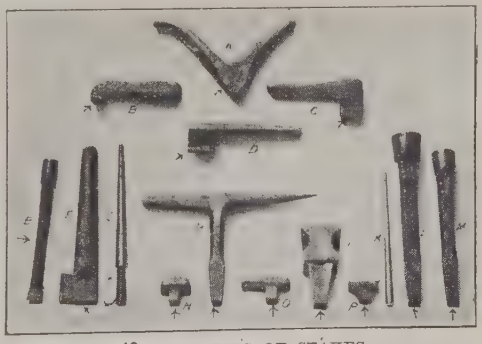
8. HAMMERS FOR ART METAL WORKERS
G and *H* are planishing hammers; the remainder are for raising, "blocking out" and "drawing in"

metal, and the short, flat ones for finishing and planishing, as it is called, with stakes, mandrels, angle wires, tee-pieces, and the like.

The detailed process of raising and drawing of a silver bowl, such as the one in the illustration, is as follows:

Cut your piece of metal from a flat sheet No. 18 metal gauge. Measure the edge of the design from the centre of the base of the bowl to its edge, and allow a quarter of an inch for cutting and filing this true at the end of the operation. Then strike out on your silver a circle, with this as the radius, with a pair of steel dividers. When this is done cut it out with a pair of shears, and then place it upon a block of wood, similar to that used by a butcher; with a hammer made of buffalo horn strike it in a series of circles, with regular blows, holding the silver at an angle of about 25° to the block [**7**]. It is better if the block is slightly concave. Then anneal it. After it is cool, take the silver again, and by holding at an angle of 30°, repeat the process of hammering again; and so on, until it is raised into a shallow saucer. After it has been annealed and pickled, turn it over on to a stake of this shape, and strike it on the outside in a similar way [**9**], turning it slowly with the left hand as you hammer it.

The important thing to aim at is to direct each blow upon the part which is immediately in contact with the stake; each blow should produce a clear, sharp, metallic ring, and in this way the silver is stretched into the shape of the stake, which should, of course, be the shape of the cup at some part or another. From this it will be gathered that the



10. VARIETIES OF STAKES
A to *D*. Side stakes *E*. Canister stake *F*. Side stake *G*. Ring mandrel *H*. Beck iron *J*. Square-faced stake *K*. Ringed stake *L* and *M*. Canister stakes *N* to *P*. Heads for vice crank

stakes required [10] are considerable in number, as it is obvious that each section of a given bowl should have its corresponding stake upon which the metal can be beaten into shape. When each complete course of hammering has taken place, the silver must be annealed and carefully cleaned. Then the operation of planishing completes the process. It is exactly the same as other hammering, except that it is performed by a short, flat-headed hammer, with a polished face. From its lowest part up to the rim the cup is slowly and thoroughly beaten with it until all other hammer marks are erased, and a regular faceting of the surface has been given to it. If it is perfectly done it should not require to be polished afterwards.

The above description will apply equally to the raising of any forms in any metals. Such metals as nickel and steel are naturally unsuitable for this work, as they are too hard.

Embossing, Repoussé, Chasing. *Embossing* and *chasing* are terms applied to the methods of enriching an object in metals by relief, produced through beating it with punches which are struck by a hammer first from the back to raise parts and then from the front to sink others, and to finish the raised parts.

The simplest form of embossing is done upon a lead block, and for large, simple decorative wrought work it is quite sufficient. But the finer kinds of "repoussé" or "embossed" work [11] are done upon a composition of pitch, plaster and oil. The great drawback to this composition is the amount of time taken up in fixing the plate to the pitch, and taking it off and re-cleaning it. But there is no other composition half so good. The tools are made from square steel rods, which are cut into lengths of 6 in. or 7 in. each, shaped at the ends according to the required line or relief. They are entirely dependent upon this and the size of the curves, or parts in relief for their shape. They are tempered straw colour at their ends. The number of tools of this kind that a chaser possesses is, as a rule, very great. As many as 150 are often required if the chaser does a great variety of work. Then he has small riffles, which are pieces of steel having at each end a little curved or flat tong of a file, either coarsely or finely grained. It is a method of work which is capable of giving great beauty and richness to metal surfaces.

After the design has been drawn or transferred to the back of a sheet of metal it is traced—that is, gone over with a flat blunt chisel-shaped tool, which is struck regularly with a chaser's hammer while the tool moves slowly along the line. The parts which are to be raised are forced up in the same manner with larger, rounder faced tools of the same convexity as that part of the relief. This is repeated, using different suitable tools until the whole presents from the other side a roughly-embossed relief. After it has been removed from the pitch and cleaned, the back now requires to be filled with pitch and placed upon a pitch block, or bowl, as the case may be. And the surface is improved by the gradual smoothing and finishing with punches. Here parts are made sharper and clearer, and there more soft and delicate. In **12** and **13** are illustrated some early specimens of art metal produced by these processes.

11. METAL REPOUSSÉ SHRINE OF FOURTEENTH CENTURY WORKMANSHIP

Casting. The central principle of casting, of which an example is shown in **15**, consists in making a mould and then pouring metal into it, or depositing by electricity. There are three ways of doing this, properly speaking—by sand, by "lost wax" ("cire perdu" or "cera perduta") or by electrolytic deposition.

The first is carried out by making a piece mould in wet sand from a plaster of wax model, and then the parts are firmly placed together in an iron box. The whole sand mould is dried, and the metal, while in a liquid state, is poured into it.

The *cire perdu, cera perduta*, or lost wax method, differs widely from the above. It is briefly performed as follows: After a plaster mould has been taken of the original model in beeswax, with the least amount of rape oil added to soften it, together with a little colouring matter, it is pressed into it, thus giving a model in pure wax. A core is inserted of brickdust and plaster, and on the outside a very solid mass of the same composition is put. Upon the model rods of wax are set on its prominent parts, passing up through the outer mould. After the whole mass has been subjected to a continuous regular heat for some time, during which the mould has been drying and the wax running out, the metal is poured into the main duct, from which it is carried through the other ducts on to the mould. By this means the whole thing is practically reproduced as in the original, as the metal now occupies the exact position of the wax, as though the wax had been transformed to metal. Further details of casting will be found in the section on Sculpture.

Electric deposition is simply the deposition of copper or silver or gold into a gutta-percha or vulcanite mould, which is immersed in a bath of solution of sulphate of copper.

Spinning and Turning. Two modern methods, which are closely allied in their processes, are spinning and turning. They are mechanical methods, and are to be decried for many reasons, the most important of which is given at the beginning of the introduction. Yet it is necessary and advantageous to know how to accomplish a piece of true spinning and turning—for this reason, that there are frequently parts of an object in metal which have to be exactly fitting and corresponding to other parts in their construction, so that they cannot be so well or quickly done by any other means. Examples of the method of making

12. CUPS AND GOBLETS OF THE SIXTEENTH AND SEVENTEENTH CENTURIES

various objects will be illustrated and described in detail.

Spinning is a method which achieves the same result upon a piece of sheet metal as is produced by hammering. The manner in which this is performed by hand without the aid of power is as follows. First a shape, in its simplest contour, resembling that of the bowl, cup, or other object, is turned in a hard wood, such as box, beechwood, or mahogany. Upon this the metal is securely fixed, with its centre placed exactly against the back-centre of the lathe. Then the "chuck," as the wood shape is termed, is revolved, carrying with it the metal disc, and while revolving, the end of the long steel burnisher is pressed with considerable force against the chuck, the handle forced underneath the armpit, and the middle of the tool supported on the slide rest, so that the whole weight of the body can be used. This is aided either by the lathe being placed as near to a wall as would allow a man to put his back against, or a leather strap fastened to the lathe, which goes round his back, thus enabling him to push with great force the burnisher upon the metal, and so press it down upon the wooden shape. When the first shape has been reached, the metal is annealed and the wood is taken a further stage. Then the metal is turned a little more into the shape desired. The metal is then again fixed against the wood, and the process repeated until the object is finished.

13. EARLY ICELANDIC CHALICE OF SILVER PARCEL-GILT

Turning in metal is similar to any other turning. Sharp-edged, chisel-shaped tools are employed, such as are shown in **14**, while the metal, solid, or hollow, or held securely upon a wooden shape, is revolved upon the chuck. These tools cut into the metal, giving the required form. All the tools mentioned are, with the exception of the lathe, of the simplest possible description. There are in large workshops innumerable varieties of most of these, but they are generally such as are for large work and thick metal. They are time-saving machines where a number of men are employed, but are too costly for small workshops. The lathe, however, is almost a necessity, for with it many things can be done with ease which otherwise would waste the time of the artist craftsman.

The most suitable metals for spinning are gold, copper, silver, brass, and pewter; and for turning, brass, silver, and copper.

Acids. The acids which are used in metal-work and enamelling are sulphuric, nitric, hydrochloric, muriatic, hydrofluoric. They are employed for different purposes.

Sulphuric acid, mixed with water in the proportion of 1 part of acid to 20 parts of water, is the most useful for cleaning copper, silver, and gold, both before and after soldering. It cleans the metal

in both cases, so that in the first place the solder runs smoothly, and afterwards it dissolves the borax. It is most advantageously used when heated to boiling point. The first operation in cleaning metal—that is, of leaving the metal in cold sulphuric acid and water—is called *pickling;* the second is generally referred to as *boiling out.*

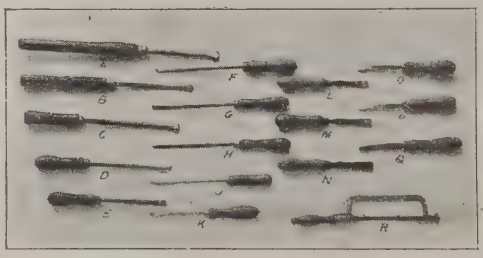
Nitric acid, or *aqua fortis,* is used in the process called *dipping* copper or brass objects. That is, after a piece of copper or brass has been cleaned in *pickle,* otherwise sulphuric acid and water, it is held on a copper wire and dipped into a bath of aqua fortis, which is commercial nitric acid. For most dipping it is sufficient to use it below the pure state. Dipping is a term given to the process of sudden immersion and removal from the bath, by which a brilliant surface is given to the metal.

Hydrochloric, or aqueous sulphuric acid, is sometimes preferred by goldsmiths for cleaning gold and giving it a yellow colour, as it dissolves the alloy of copper. It is also occasionally used in cleaning copper, particularly when it is to be electro-gilded afterwards. The most general use to which it is put is in what is termed "soft soldering," that is, soldering with pewter solder. For this purpose the acid—or, as it is popularly called, *spirits of salt*—is killed by dropping particles of zinc into the acid, which is then put upon the parts to be soldered.

Aqua regia is a mixture of hydrochloric and nitric acid.

Muriatic acid is largely used in colouring gold articles.

Hydrofluoric acid attacks any kind of enamel or glass. It decomposes the silicates, which are the chief parts of glass. For the purpose of removing any portion of the surface of enamel, or for dissolving it entirely, this acid is the only one which can be employed. It is a very dangerous acid, and should be used with great care.



14. VARIOUS TOOLS
A to *E.* Tools for spinning *F* to *K.* Turning tools
L to *Q.* Screw-cutting tools *R.* Hack-saw

Polishing. If a surface of metal be rough through filing, the method of smoothing and polishing by hand is as follows. Take rough emery cloth and rub it all over until the file marks are removed; then use a finer emery cloth, in grades, until the finest is used. After this, take powdered pumice and oil, and with a stiff brush scrub it all over until a smooth surface is obtained. Then, with a soft woollen or worsted material and rottenstone mixed with oil, rub it again, when a dull polish will be given. Then, with a chamois leather and rouge polish it brightly. To polish in a lathe the same means are employed, save that mops, buffs, and laps are employed, fixed on the chuck.

Burnishing. By the use of a burnisher, either of steel, hematite, or agate, a still higher degree of polish can be obtained. Burnishers are made in all kinds of shapes to meet the requirements of the article to be burnished, and are used with a little soapy water. Continual light rubbing in various directions, while the object is held rigidly in a piece of fine tissue paper or chamois leather, produces a brilliant burnished surface.

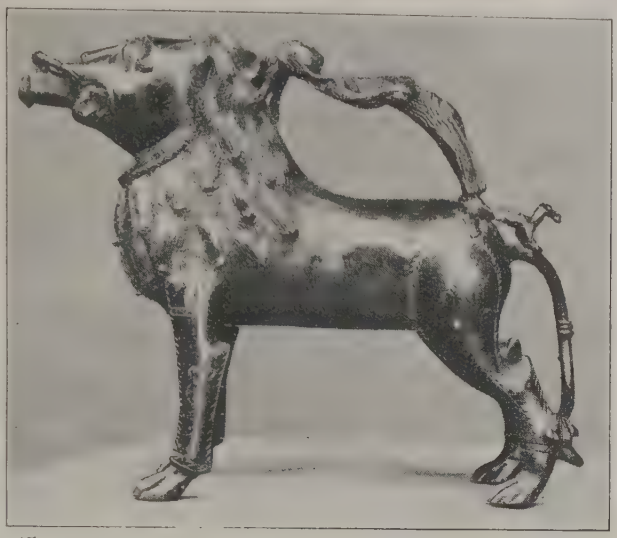
Engraving. Properly speaking, this art is the oldest of all known methods of enriching metallic surfaces, as it is found in the earliest periods of the Bronze Age. For with a pointed instrument made of hard stone, such as a flint, it was found that a line could be scratched or cut in the metal. From this to the exquisitely engraved work of the Irish Celtic jewellery [16], and later of the fifteenth and sixteenth centuries, is, after all, a small step in result, yet it took ages in its achievement. The great obstacle in the development was the tardiness with which the discovery of steel was made. From the smelting of bronze to that of iron whole periods of the struggle for existence and for man's development passed away. Then, from the forging of iron to its conversion into steel, even in the most primitive form, necessitated long stretches of time in human advancement. The conquest of material and the subjugation of natural forces to man's will is a slow one, even when, as now, the greatest talent is devoted exclusively to that particular direction and aim. When the mind has been taught to rely upon itself for aid, and has been slowly but laboriously disencumbered of all the wild phantasmagoria inherent to the savage man-child, we come to the development when we can go out and obtain in the simplest fashion the steel graver of to-day.

Engraving Tools. Yet no discovery which simplifies things for the many is entirely without its drawbacks for the individual. The tools which, as in this case, are to be used directly by the hand must be such as will suit the hand of the operator using them. Therefore, when you have purchased them, the first thing you will find is that it is necessary to shorten the tools and cut the handle to the shape of your own particular hand. Many engravers find it advantageous to employ a long handle with a small, roundish head that will fit into the palm of the hand. Others prefer a short handle. Again, most of the tools, gravers, spitzsticklers, scorpers, etc., are cut at a too oblique angle for metal engraving—which causes the edge to be liable to break. The first thing to do, then, is to make the tool and handle fit your own hands. If you find it advantageous to shorten the tool, you must first of all soften the steel by heating it to a pale red, and then allow it to cool, after which you file it down, smooth it up with emery cloth, and then temper it as already described. Then sharpen upon an oilstone (fine Turkey stone is the best, and should always be kept clean and covered, to protect it from dust). In sharpening, take care not to cut the stone into grooves, or you will spoil it, and it will be of no further use.

The next thing to do is to fasten your plate, or cup, or whatever the object is, firmly upon a stick or block, as the case may be. For small work, such as a ring or pendant, place some melted resin on the end of a round stick, then warm the resin, and fasten the article to it. If, on the other hand, the object is a cup or large object, fill it with pitch and put it upon a pitch block as though for chasing. Then hold the arm rigidly, the thumb pressed firmly against the plate, and by pressing with the back of the hand forward and rotating the stick —or block—in a contrary direction as the design may require, the line will be cut. It is obvious that the tool must cut along laterally, and not in a

downward direction, and it is by constant practice that this is acquired. The line is then cut deeper and broader, according to the boldness or delicacy desired.

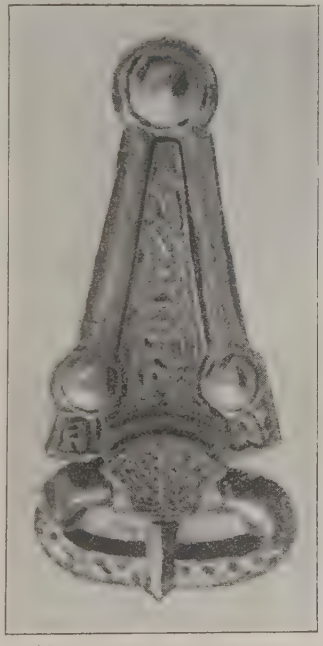
For different effects the line is cut hollow, curved, V-shaped, or flat; for each of these the tool must be accurately made. It is a good thing to practise cutting all sorts of curves by different gravers and to compare the result, and then to examine the best work through the knowledge thus obtained. For damascening, niello, and enamelling the same process is employed, with this sole difference—that the parts in which the gold or silver is to be let in the steel, as in damascening—or the sulphide of silver and lead to be melted in as in niello, or the enamel fused in the spaces cut out as in champlevé enamelling—are cut much deeper than is the case for engraving simply. These latter processes will be described under their proper headings.



15. FLEMISH CAST, BRASS EWER OF FOURTEENTH CENTURY

Engraving on a small scale, either for gold, silver, copper, brass, or iron, is invariably done by the unaided pressure of the hand holding the graver. But for large work, such as memorial brasses for inscriptions, hammer and chisels are used. In this case the chisel is held in the left hand and struck with a chaser's hammer, much in the same way that repoussé tools are used, save that, instead of beating the chisel while holding it at right angles to the surface of the metal as in repoussé, the chisel is held obliquely at about an angle of 45°. Little pieces are flaked off at about every third blow. Another method is properly described as etching, but it is often erroneously referred to as engraving by acid, and does not come into this category.

Die-sinking. Die-sinking is very intimately connected with engraving and carving. Carving is very rarely done, as metal does not yield to such treatment as well as to other methods described. But die-sinking is one of the most common of the operations to which metals are subject, and it is at the same time a distinct method, so that it requires adequate description. It is generally used in striking medals, coins, badges, or other articles in bronze, copper, silver, or gold, in which fine detail is required, and where the work is to be reproduced many times. A block of steel is used. It measures across the face a little more than the piece to be struck, and deep according to the size of this face, in order to withstand enormous pressure. Then, upon this prepared surface—that is, a perfectly true smooth surface—a mould is carved with steel chisels, gravers, and riffles. A very careful model is made in plaster, and is then copied in the steel. It is a work which requires the greatest knowledge of the use of tools, as well as the most careful, concentrated effort. A really fine knowledge of form and modelling is absolutely necessary. While the process of carving or die-sinking is in progress, wax impressions must be repeatedly taken in order to see how the work is going on. When it is complete, the surface must be tempered, and, upon this being satisfactorily accomplished, the die is placed in a press, or underneath a heavy bolt, raised by a pulley and dropped, and the metal disc is struck. If the die is not properly annealed and tempered it will crack in this process. The metal disc also must be of the softest description and carefully annealed.



16. SILVER-GILT FILIGREE BUCKLE

Niello. Niello is an inlay of an amalgam of silver, lead, and copper, in the proportion of 12 parts of silver, two parts of copper, and one of lead, to which is added powdered sulphur in excess while the mixture is in a fluid state in the crucible. This is pulverised when cold, and into the engraved parts of silver, gold, or copper the powder is placed. But before doing this it is necessary to apply a little borax, and run it well on to the engraved parts, then the powdered amalgam is shaken all over the metal thickly and baked. After it is withdrawn and the defective parts mended, the whole is rubbed down with files and emery, and finally polished. It was at one time very largely used upon silver. A considerable amount is still done in Italy and Spain, but it has never been very much in request in England, probably owing to its absence of colour. The great examples are the altar frontals at Pistoria Cathedral and at the baptistery at Florence.

Goldsmith's Work. The jewel in the illustration [19] is built up of separate parts. First the vase shape is made by beating out a strip of metal the length of the circumference, and then the part immediately above it, first as a cone, the lower edge of which is spread out on a mandrel; then the base is beaten out of a small circular disc, in a saucer shape, and these pieces are soldered together. The granular surface is obtained by soldering grains of gold upon this. The simplest method of making these is to cut up minute pieces of gold wire of exactly the same length, and melt them on a charcoal block, pressing the pieces into the charcoal. Then, after picking them out of the charcoal, they are shaken together in a bag, and afterwards rolled gently and evenly by hand between two true flat steel plates. By this means the grains will become spherical. A little calcined borax is mixed upon a slate, with water and gold solder filings added; a paste of this is made, and put on the gold. Now, with a mouth blowpipe, this is melted all over the surface. When this has been done, and it is quite cool, the grains are placed regularly upon the surface, and with a little gum tragacanth they are fixed. Then the flame of the blowpipe is blown gently upon them, drying the gum, and taking it up gradually to a red heat, so that the solder just melts, and causes the grains to adhere to the surface.

17. GOLD ARMLET

Many of the Etruscan jewels, such as that shown in **20**, were enriched in this manner. The making of the filigree is of the simplest description. Take a small wire, flatten it with a small hammer, and bend it round with round-nosed pliers. Then tie it in position with fine iron binding wire, and solder it to the main piece in the manner already described.

The armlet illustrated in **17** could be quickly and efficiently made by hammering the cylindrical shape in two halves from a piece of fine gold, of No. 10 metal gauge, by soldering them together, and then by cutting out the bird form in a thick piece of gold and soldering it with 20-carat gold solder. The head, horns, and paws are also made out of thick sheet metal and soldered to the body. Then the settings for the stones, which were in the body, are soldered on also. The probable way in which this was made was by modelling in wax in a cone, and casting, and afterwards chasing. This method is a good one, and is the best, as well as the simplest, but the cost of the solid gold would naturally be very considerable.

Silversmithing. The cup shown in **24**, of which the author once made a replica, is one of the most highly admired objects in the South Kensington Museum. It is of silver-gilt, and round the cup and cover it has pieces of green enamel *plique à jour*. It is not so much an elaborate work of art as a perfect piece of refined taste and craftsmanship. The principal excellence is the exquisite finish and proportion. The mode of its manufacture is as follows.

The body of the cup is hammered out of a sheet of silver, as described briefly in the general remarks under Hammering. A circular piece of sheet metal, of No. 18 metal gauge, is cut out with shears. The width of the base is struck out with compasses, and then, upon a wooden block, the metal is beaten into a series of rings, the metal being held at an angle of about 30° to the block, and, after annealing, the operation is repeated at a greater angle, and so on. Then it is turned over on to a stake and beaten from the outside, and thus drawn in. Finally, it is planished and polished. Now upon this is marked out the exact position of the mounts to hold the enamel. These mounts, made from a thick piece of wire, are chased and drawn by hammering, chiselling, and filing. Then the enamels are made as described under Plique à Jour. Now cut out the spaces, and upon the body pounce with a sharp graver the pattern. After it has been gilt, the enamels are fixed. A more ornate sample of the same class of work is shown in **18**.

Wrought Iron and Steel. From the fashioning of armour plate, the forging of a damascened and jewelled Toledo blade, to the humble smithing of a horseshoe, from the making of an anchor to a grille or lock-plate, forms a fascinating study of work in iron and steel. Of late years, the smithing of iron has become one of the finest crafts.

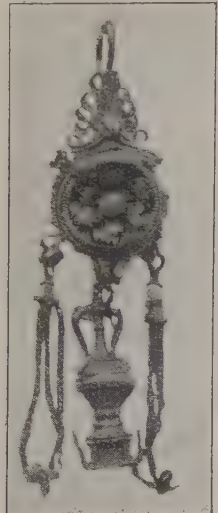
In ancient times, when all objects of utility, as well as of adornment, were marked with a desire for beauty, when the most frequently used kitchen meat-jack was regarded not only as a thing of use, but also as something that might be made beautiful, iron-work flourished in all its excellence. Contrast the iron-work of from 50 to 100 years ago, when it was deemed sufficient if it served its purpose and nothing more, with such work of ancient times—with the hinges illustrated in **21**. Why is it that a piece of engineering work is generally ugly? It

should be that the tool, or structure, which serves its purpose of utility best should also be the most beautiful, for beauty depends more upon the fitness of intention to purpose than upon anything else, and any extraneous adornment or unsuitability, or unnecessary feature, should signify a defect in design. And so it does. For, rightly considered, it is always the beginning, and therefore imperfect engineering or mechanical inventions which are ugly, and as they grow to perfection as things of utility they become less ugly.

Iron and steel are the most useful of all metals, but most of the ironwork, engineering or otherwise, which one sees is not beautiful, principally because it either fails in its purpose or does not completely fulfil it. The main characteristics which distinguish iron and steel from other metals are greater ductility, hardness, and infusibility. They oxidise more freely, and possess the property of becoming welded under pressure, produced generally by hammering when heated to a soft state. Steel, which is carbonised iron, differs from iron in that it is much harder and more brittle, but less malleable and ductile.

18. EARLY GERMAN CHRISMATORY

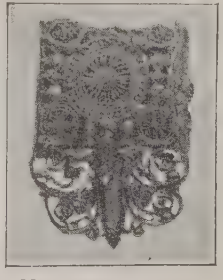
Varieties of Iron and Steel. There are substances lying intermediate between iron and steel; these are hard irons and soft steels, which depend upon the amount of carbon introduced into the iron. They are employed in a variety of ways. The most suitable iron for wrought purposes is almost pure iron, and contains but one-tenth per cent. of carbon. This will not harden under any circumstances, and welds readily. It is fibrous and tough. The greater the proportion of carbon in the composition of steel, the harder it is. It fuses at a lower temperature, it is granular, very tough, springy, and capable of being made soft, hard, or brittle. The very earliest forms of wrought iron show that the ore used was obtained from meteoric ore, as nickel is discovered in it when analysed, and there is a certainty that they were unable to smelt the ordinary ore. It was the custom, due to necessity, for the earliest workers in iron and steel to make all their own tools, and we know nothing which is better training than this. For to make a file, a pair of pliers, a repoussé tool, a mandrel and a graver, requires a great amount of knowledge and skill, and no doubt assisted the apprentice in obtaining a mastery over his material which, in most other ways, would be insufficiently acquired.



19. GREEK GOLD EARRING

In Theophilus' book we read of the method employed at that time in making steel and iron tools. The principal operation in wrought iron which distinguishes this work from all other kinds is that of welding. Welding consists in making two pieces of iron red hot, and consequently soft, and while in this condition, of hammering them together until they form one piece. It is the most complete union in all metalwork, for it is the absolute junction of two separate parts of the same material by itself; whereas, all other metals are joined by a solder of some kind. The most general methods of wrought-iron work are bending, chiselling, welding, riveting, and hammering.

Methods of Working Iron. Bending of thick iron is always done while the metal is red-hot, either upon a mandrel, in a vice, or upon an iron shape, and as it is heavy work, it is done by a man and his assistant. While one holds it securely with tongs or places it in a vice, the other beats it with a hammer, or twists it with other tongs. With leaf work, the iron is cut out from the sheet to a template, and is generally beaten into different shapes while cold, or if thick, while hot. Rods of all sizes, sheets of almost any thickness, strip of any gauge, can be readily procured from the metal merchant. In the forge, fine breeze is used, so that it falls closely round the iron. Small breeze burning is used with the bellows. It requires quick handling. In the making of any part, the best method of procedure is to make a pattern or template, on which the scroll or curve can be tested. In making thin work, it is scarcely necessary to heat at all, save for welding; but we deprecate very strongly the employment of thin iron out of doors, as in this climate it corrodes quickly. But a different set of tools and much greater skill is required



20. ANCIENT GREEK GOLD EARRING

21. MEDIÆVAL FRENCH CHEST HINGES

in dealing with thick iron. When using thick iron bar, the simplest way is to bend it by striking it over the anvil, or over shapes fixed in a vice. The anvil, owing to its tapering, circular, and flat ends, can be used for almost every variety of curve. The ease with which iron can be bent while red-hot is one of its sources of danger, inasmuch as it is apt to shrink, unless held firmly and beaten slowly. The geometrical volute in the scroll is never to be commended. It is one thing that the wrought-iron worker usually seeks to achieve, and it is a good thing to be able to do it easily, but only so that something better may be done in which the curve is one thought out and studied. As one walks along the street he notices that it is the most common form employed, and the result is dismal.

Cast Iron. The description of the method of casting in iron [22] will be given under Sand Casting. It is sufficient for our purpose to compare cast iron with wrought iron. Now, there is, so far as craftsmanship and treatment, no comparison in all such work as grilles, screens, and such places as require lightness in design. But where more massive work is required, such as newel posts to a gate, or large fire-dogs, or relief for the back of grate, then cast iron, suitably designed and handled, has its proper place. The work of Alfred Stevens in this material is, in some respect, the finest that has been done; but in spite of his great name, commend us to the work of some of the German and English cast-iron craftsmen of the early part of the fifteenth century. For iron suggests strength of a rude, simple kind; massive, blunt, heavy, solid, and full of power, not the polished, curving, adaptable, pliable, facile substance that copper or silver is. This remark applies largely to wrought iron as well as to the cast variety, for thin wrought-iron work is very unpleasant. We have frequently found wrought-iron railings with twisted scrolls and leaf work that you could break off with your fingers. Imagine what they will look like in a few years, when no amount of paint will hold them together. Again, one frequently sees parts which should have been welded held together by solder. Architects who pass such work are culpable through ignorance, indifference, or neglect.

22. CAST-IRON GONDOLA PROW, VENETIAN

Enamels and Enamelling. Enamels are composed of silica, minium, and potash fused together and combined, when in a state of fusion, with oxides of metals by which they obtain their colour. The chief oxides employed are those of cobalt, copper, iron, manganese, tin, and lead. Copper gives green, turquoise, and red. From iron, red, brown, and orange are obtained; manganese gives purple and cobalt blue. Tin and lead combined and calcined are used to make enamels opaque. All enamels are transparent before this calx—of lead and tin—are added. Chlorides of gold give ruby and silver yellow. These enamels are made in a crucible, and when properly run down into a clear vitreous mass are poured out into water. By doing this a great amount of time is saved in the subsequent operation of grinding, which is the next part of the process of enamelling.

23. PASTORAL STAFF, LIMOGES CHAMPLEVÉ ENAMEL

Enamelling is divided into five processes — namely, Champlevé, Cloisonné, Bassetaille, Plique à Jour, and Limoges, or painted enamels.

Champlevé Enamelling. Champlevé enamelling, of which a specimen is illustrated in 23, consists of two separate processes of engraving or carving and then filling these spaces in with enamel, and firing. A plate of copper, silver, or gold is taken and put upon pitch or resin attached to a bowl or stick (as described under Engraving), and the pattern sunk with a flat scorper to about one-sixteenth of an inch in depth, leaving the dividing outline of the pattern raised. Then the enamel is pulverised with a pestle and mortar in water until it is a fine powder. Now it is washed so that all the milky part is entirely removed, after which it is put into

a saucer, and with the aid of a spatula or a brush the sunk parts are filled up with the granulated enamel. It is now dried at the furnace, and when the furnace is of a pale red heat, it is slowly and carefully introduced, supported on a fireclay or iron planche. When it has become shiny it is withdrawn and allowed to cool. This is then examined, and if any parts are below the surface of the raised metal lines they are filled up again as before and fired once more. It is once more removed from the furnace and upon examination it will be found to have some parts raised beyond the others: these are ground down with a corundum file and water, and then refired.

24. BEAKER, WITH COVER, FIFTEENTH CENTURY

Cloisonné Enamelling. Cloisonné enamelling differs from the preceding only in the process of its preparation for the enamel. In this case the cloisons or flat, thin strips of metal, either gold, silver, or copper, are soldered to the metal surface to be enamelled. When the plate has been cleaned in "pickle" (sulphuric acid and water) the spaces are filled in as before and fired.

Bassetaille. This is a process in which the metal is carved in relief below the general surface of the surrounding metal. The metal is cut sharply with gravers and scorpers. It is most advisable first to make a careful model in wax, and then to copy it in the metal. Then fill in and fire. There are no metal divisions in this case, but by careful handling the edges will not mix, and they do not do so in the furnace unless greatly overheated.

Plique à Jour. Plique à jour is identical with cloisonné enamelling save that there is no background of metal to which the wires or cloisons are soldered. They are simply soldered to each other and between these spaces the enamel powder, mixed with gum tragacanth, is placed, dried carefully, and fired on a support which touches the edge of those parts where there is no enamel. This, for simple work, is very effective and easy. For more elaborate work such as a bowl or a cup, the metal cloison is laid upon a metal or fireclay base, which is filled in and fired as described for champlevé; and the base is afterwards removed either by acid or some other solvent.

25. ENAMELLING A PLATE ON WHICH THE SUBJECT HAS BEEN DRAWN IN IRIDIUM AND FIRED

Limoges or Painted Enamels. These enamels [26] are different in their manufacture from those obtained by the preceding processes. The sheet of metal is slightly domed so that it rests upon its edge. Underneath, it is covered with one coat of finely-ground enamel about one-eighth of an inch thick, and when this has been thoroughly dried it is turned over and the front is enamelled with a layer of rather coarsely ground enamels. The metal has, of course, been thoroughly cleaned as described under Pickling, before the enamel is spread upon it. This first layer is fixed and repaired, if necessary, until it is quite clean and bright. Then, upon this the subject or design is painted in white enamel, very finely ground with water, or with a glass muller upon a glass slab. With a brush it is then painted upon the prepared enamel plate [25]. A great degree of modulation can be given to this white by putting it on in varying thicknesses, and 27 is a good specimen of this. After firing, it is covered with transparent enamels and fired again.

Another most advantageous and peculiarly characteristic part of this process is the use of foil. Just as foil is used to heighten certain stones so it is used to heighten enamels. These paillons of foil are cut out and stuck upon the enamelled plate, after which the different coloured enamels are fused upon them. There is a great tendency to use foil, which should be guarded against as it is apt to give a meretricious effect.

The whole work is now taken in hand and parts are still further enriched with gold lines. The effect of a finely painted enamel is one of the most beautiful things it is possible to produce.

Sand Casting. Sand casting is generally employed where simple surfaces and planes are the dominating feature of the model. In preparing the model it is obviously necessary to bear in mind the process in which the work is to be carried out. For sand casting this should be arranged so that the mould in sand will draw easily in the fewest possible pieces. Sand casting is very largely the equivalent of plaster casting from a piece mould. In *cera perduta* the model may be of any shape, undercut, and of the most uneven and intricate

design. But the reverse holds good in sand casting. In modelling for small work such as jewellery, it is a great advantage to use rather a hard wax, which can be done with ease if it be warm, so that when it is cold it will set hard enough to press the mould from it. The larger the work the more desirable it is to have tools and appliances, but for jewellery the simplest mould in plaster and brickdust—or a sand mould—is sufficient.

The sand, which is finely prepared, is put into a box and pressed down in a wet state, until it is almost a solid mass. Upon this the impression of the mould is made. Then the reverse of the model is taken in the corresponding half of the box. A V-shaped hollow is cut from the inlet of the box on to the impressed mould and then the sand is dried. Charcoal powder is now sifted all over and the melted metal is poured into the mould from the crucible. This, in the simplest possible terms, is how sand casting is performed. From this groundwork the most elaborate system of casting has been built up. The elaborations consist in making the pieces, or piece moulds necessitated by the different planes of the model. If these are numerous, as in a group of figures, it naturally involves a great amount of careful planning and execution. All such pieces are united with iron or bronze pins, as the case may be, and the core or heart of the mould is fixed in position also with pins, in order to keep the inner edge of the mould and the outer surface of the core in their exactly separated positions; then the metal in a liquid state may run between them. Any parts of the mould, such as arms or legs of animals, or figures which are extended, are usually cut away from the main trunk and cast separately. They are joined afterwards by brazing or soldering and riveting—a process which simplifies the casting considerably. Most of the work which is not large in dimension and is composed of many surfaces is now cast in the lost wax, or *cire perdu*, process. To compare these processes would be invidious, for so much depends upon the skill of the artisan. But the above is a guide to their differences and advantages.

26. ENAMELLED PLATE IN VICTORIA AND ALBERT MUSEUM

27. PLAQUE OF COPPER PAINTED IN TRANSLUCENT ENAMEL COLOURS

General Considerations. It is hardly necessary to dwell further upon the various processes of metal-work or enamelling, or to elaborate in detail the intricate problems which present themselves in the practice of them. But it is as well to point out that the failures which everyone has to encounter at the beginning and during the pursuit of any art work, or, for that matter, any kind of work, and especially in its higher branches, wherein the element of chance so largely enters—such as in the case of repeatedly firing a piece of painted enamel—must all be considered as incidents by the way from which it is possible to derive valuable knowledge for future work. For the cause of each failure rightly accounted for and successfully overcome is a step on the ladder of achievement. Failures, then, should never be regarded in the light of discouragement and despair, but as obstacles in overcoming which increased knowledge and strength is gained.

It is most important also to bear in mind that the best results can be obtained only from a material by observing its properties and capabilities first, and never imposing conditions upon it which are foreign to its nature and composition, which will militate against success, but always endeavouring to express the true essentials of these properties. That is to say, the full appreciation of the fact that material (be it metal, enamel, or any other) which is taken up for the expression of an aesthetic emotion is in many respects both master and servant. By a rapid survey of work in which a misapplication of a material has been employed one can see what to avoid—such as in the case of mouldings, columns and capitals made in stone or wood which have been copied in metal, or, again, where the forms of natural flowers and leaves have been closely imitated, and made as though they were growing out of a wire on the side of cup.

ALEXANDER FISHER

Soil. Drainage. Manuring. Rotation of Crops. Seeds. Sowing. Transplanting. Hot and Cold Frames. The Common Vegetables. Monthly Programme. Choice of Seeds.

VEGETABLES & THEIR CULTIVATION

ANYONE who wishes to become a successful vegetable grower must watch carefully the progress of the infant plant, learn its habits, needs, likes, and dislikes, for only in this manner can he realise its possibilities, and thereby grow it to satisfaction. The germination of the seeds it is desired to sow must be studied; the suitability of the soil, climate, and aspect must also be considered. The markets that are available for the produce, and the class of vegetables most suitable for them, and whether there is sufficient local labour to attend to the harvesting of the crops, are all factors in the making or marring of the enterprise.

Very often there is a great waste of time, money, and labour, particularly with beginners, because they attempt too much, trying to grow too many different kinds of plants, when they would reap much better results financially by selecting only a few of the varieties that are most suitable for their particular conditions.

The wisest course is to grow the best of everything, and nothing but the best, and to leave severely alone anything of which the best cannot, owing to local or other conditions, be grown. The very first axiom to keep in mind with reference to land used for vegetable growing is that its productiveness must be strained to the utmost. No fallowing or resting of the ground must be allowed; it must always be under cultivation, one crop succeeding another in rapid succession; and if, as sometimes happens, the market is low and prices are bad for the particular vegetable that is ready, it should be dug into the soil, and it will pay well as a manure, this being particularly the case with such crops as cabbage, turnips, and greens. They should be buried in trenches, and other crops sown over them. It naturally follows that if a great deal is being taken off the ground in the way of crops, a great deal must be put back into the soil in the way of manure.

Selection of Soil. The selection of suitable soil for growing vegetables is of vital importance, and this fact cannot be too forcibly impressed upon the beginner. In some cases a piece of land that has been reclaimed will yield a good profit the first year, while in others, even after years of labour and the spending of large sums of money in manure and draining, the desired productiveness cannot be obtained. Many a man has made his initial mistake by the selection of an unsuitable soil.

Without question, the best soil for vegetable growing is one of an alluvial saline deposit, but this is very seldom found far from the sea. It consists of a dark, heavy loam, and can easily be told by the quantity of decomposed shells that will be found in it. Failing this, a somewhat lighter soil, from a foot to 18 in. deep, with a subsoil of yellow sandy soil, should be sought. Another good soil is one that is even lighter, the sand being in greater proportion than the loam, but this soil is almost useless for growing cabbages, celery, or onions. For those crops that are not required early, a soil that is known as clayey loam is best. It consists of a loamy soil with a percentage of clay in it about a foot in depth, and having a subsoil of stiff bluish clay, often spoken of as gault.

However, whatever the original state of the soil, whether of the garden or field, it will always admit of being brought to a greater state of fertility and productiveness. The soil, to be in first-rate condition—and this should be the aim of every serious grower—should be deep, rich, and moderately light, besides being well drained. Therefore, if the ground is wet, it must most certainly be drained.

Drainage. The systems and methods employed in the drainage of land naturally vary according to circumstances. For instance, a man may be a long way from any place where he can obtain tiles or clay pipes, whereas he may be able to obtain without any trouble creosoted boards or brushwood, and at a reasonable price [3]. Before starting any scheme of drainage it is necessary to find out the fall of the land—that is, the way the water naturally flows. A trench three or four feet deep has then to be dug across the field in the direction the water flows. In the bottom of this is placed a quantity of brushwood, medium-sized stones [2], flat stones, clay pipes, arched tiles, or wooden culvert, and the earth filled in again. If there is no outlet such as a ditch for the water to run into, a large pit must be dug that will form a pond by the water running out of the field into it.

Preparation of the Ground. The operation next in importance is that of aerating the soil—that is, allowing plenty of air to enter the earth, so that nutritious gases are assimilated, and food thus prepared for the plants that are to follow. This is accomplished by the process of what is termed *trenching*. The soil is removed to a depth of two or three spades, and into the trench thus made is thrown the top surface of rough, unbroken clods from the next strip or row that is to be dug, and the earth piled lightly up. With stiff, heavy land it is very important that it should be ridged before the winter, so as to expose as much of it as possible to the beneficial influence of frost which will crumble it up. At the same time, as the soil will be more or less broken and but lightly piled up, it will be in a better condition for the atmosphere to act upon it.

When preparing a large field for vegetables it will naturally be impossible to dig it all over by hand, and in these circumstances it should be subsoiled in the manner indicated in the chapter dealing with the preparation of the land for planting fruit trees. [See page 5060.]

The ground should always be thoroughly turned over two or three weeks before it is desired to use it for vegetables, that it may be sweet and loose to receive the plants or seeds. With heavy land it is also a very good plan to give liberal dressings of such materials as sand or road grit, cinder dust, or builders' rubbish, which will greatly help to lighten it up and make it work easier. When the land has been treated in this manner early in the winter, it will always be found profitable to spread over it a heavy application of stable manure.

With the approach of spring a coating of lime should be given, as most soils are deficient in this, and it should also be levelled. A trench should then be dug about 9 in. deep and about 6 in. wide, and the soil scattered on the land that is about to be dug over. Begin digging again at the end of the row, throwing the soil into the trench that has been made, taking care properly to bury the manure that has been lying on top of the ground all the winter, and any weeds that may happen to be about. All clods should be thoroughly pulverised and the surface made level.

Manuring. There is a great tendency on the part not only of amateurs but also of professionals to get all they can out of the land without putting much—if anything—back into it. This is undoubtedly an error of no mean importance. If more than those that have been receiving applications for several years. Clay lands and lands where a good deal of vegetable matter has been ploughed in will profit with a much heavier dressing than light soils, and it will be found that where lime is used liberally on stiff and heavy land the crops will be heavier, better, and earlier than previous ones.

Useful manures, other than stable and farmyard, are soot, carbon manure, fish and Canary guano, and the usual artificial manures.

Rotation of Crops. Nothing pays better than system in this industry, as in every other; it is therefore necessary that there should be a rotation of crops. By rotation is meant changing the crops, so that the same is not grown on the same piece of land two years in succession. It is better still to leave an interval of three or even four years.

	SECTION 1	SECTION 2	SECTION 3
	Time to Crop—Kind of Crop	*Time to Crop—Kind of Crop*	*Time to Crop—Kind of Crop*
2′	Early in March, and succession Potatoes	Middle of March Beans	End of February Early potatoes. (Radishes to follow.)
		Early in March Parsnips	End of February Cabbage. (Lettuce to follow.)
		End of February Carrots	Beginning of March Early peas. (Radishes between rows.)
		End of February Onions	Beginning of March More early potatoes. Plant broccoli as soon as these are dug. (Celery to follow.)
		End of March Beans	End of February More early potatoes. (Celery to follow, and lettuces should be planted on ridges of trenches.)
		Early in May Turnips	End of February Early peas. (Follow as above.)
		Early in May Beetroot	End of February Lettuce. (Cabbage to follow.)
		Early in May Scarlet-runners	End of March Cauliflower. (Turnips to follow.)

1. DIAGRAM ILLUSTRATING THE ROTATION OF VEGETABLE CROPS

vegetable growing is to be made to pay, the very best vegetables must be grown, as there is ever plenty of second-rate stuff flooding the market. This production of the best cannot be accomplished without the aid of large quantities of manure. One of the most successful market-gardeners, and a man who has been in the business for over twenty years, uses from 50 to 100 tons of well-rotted manure per acre every year. The manure should be well rotted and thoroughly incorporated with the soil, otherwise injurious insects will breed in large numbers, and club and canker will do immense damage among the crops.

Lime is a very important factor in the production of garden crops; it sweetens and assists in pulverising the soil. The quantity to be applied per acre varies according to the soil, some land being far more deficient in it than others. Grass fields when first ploughed up naturally need a great deal

As an illustration of how this is arranged, suppose we take an acre of ground and divide it into three plots or sections, with a space of about 2 ft. between each section [1]. The whole of the land that is to be cultivated with vegetables can be treated in the same manner, whether it be a small kitchen garden or a 400-acre farm. Of course, in the latter case separate fields would be set aside for separate crops.

Having formed our sections or plots, the diagram will serve as a guide to the crops that should be grown on them. A path about 1 ft. wide should be left between each kind of crop, so that they can be properly cultivated without damage to plants growing by the side.

Storing Seed Potatoes. It is becoming more than ever the practice, before the winter, to place in shallow trays, like that shown in **13**, seed potatoes that are required for early sowing. They are kept in barns [**12**] or stores, stacked one on top of

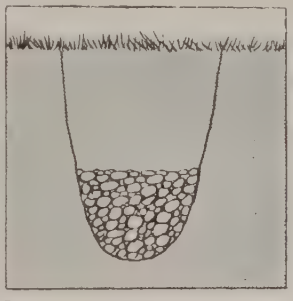
the other, with plenty of light ; and the temperature is kept above freezing-point by means of small oil-stoves. About once in three weeks the tiers of trays are taken down and restacked, placing the top trays at the bottom of the new tiers, so that the shoots are all strong and sturdy. If this is not done, it will be found that those in the bottom trays will have long, weakly, white shoots that will easily be broken off in planting.

By this method of boxing it is possible to plant them later, and so run less risk of their being cut off by frost. They will still be ready for market by the time those that have been sown earlier and not boxed are ready to be dug. Moreover, if the grower has a sheltered field, he can sow them at the same time as those that have not been boxed, and so have them ready for market much earlier.

The dimensions of these trays are 2 ft. 6 in. by 1 ft. 6 in., the sides and bottoms being made with $\frac{3}{8}$ in. wood ; the corner supports are made $1\frac{1}{4}$ in. square and 6 in. high, the sides are $3\frac{1}{2}$ in. high, and the handle $1\frac{1}{2}$ in. by $\frac{3}{4}$ in. A little space is left between each of the bottom boards to permit the air to circulate through.

As soon as these potatoes have been dug, the same ground should be immediately planted with broccoli, cabbage, or spinach, for use in the winter or the following spring.

As soon as the crops have been harvested off the second section the ground must be trenched ready for the main crop of potatoes for the following year.



2. FIELD DRAIN WITH STONES AT THE BOTTOM

Choice of Seeds. The question of seeds and the correct time to sow them is of vital importance, and it will be found that in the long run it pays best to buy one's seed from a reliable nurseryman, and not from dealers or agents. This will ensure that the seed is fresh ; seed that is stale has lost much of its germinating power. Care should be taken to procure seed that is pure and true to its name. It requires years of experience to say with any authority to what particular variety seed belongs, but to test its germinating powers is a simple matter. The most satisfactory method is that employed by large nurserymen, and consists in planting a certain amount under favourable conditions, and watching results. The plots on which such seeds are grown are termed testing grounds. In this case the seed will be a year old when sold, but will still be fresh enough for good germination. A quicker though more rough-and-ready method of testing seeds is that described in the chapter on the Propagation of Fruit Trees. [See page 5566.] The term "freshness" needs qualifying, as certain seeds are as good, or even better, after they have been kept a year or more than when quite new.

Parsnips, onions, and leeks should be sown the first year after they have been harvested. The keeping power of other seeds is : TWO YEARS : Thyme, beans, sage, peas, rhubarb, carrots. THREE YEARS : Parsley, asparagus, spinach, lettuce, radish, endive. FOUR YEARS : Cabbage, broccoli, turnips, cauliflower, celery. FIVE YEARS : Beetroot, cucumber, marrow, tomato.

The vitality of the last four is such that they can be kept even for seven or eight years. These facts should be borne in mind, as some seasons are unfavourable for the proper ripening and maturing of seeds. In cold, wet summers it would be better to use older seed that had been properly harvested.

It may be of assistance to the small grower to know that if the prices for a particular crop in any season are low, it may pay him better to let it run to seed. In the case of annual plants such as peas, beans, radishes, lettuce, and the like, the seed should be taken from those first maturing. In the case of biennial and other plants such as beets, carrots, parsnips, onions, celery, and cabbages, the method of raising the seed is to select the best roots before the winter and replant them in the spring.

Early and Late Sowing Varieties. The novice or amateur may say that he has known some of these biennials go to seed the same year that the seed was planted, but in these cases it is safe to say that some unnatural factor has been at work. Seed sown too early, with a mild autumn following, may thus obtain a longer season and be induced to become annuals. In the circumstances it may be helpful roughly to divide the various seeds into two classes—those for early sowing and those for late sowing. *Early sowing* corresponds to the period when the average temperature in the shade is 45° F., which in our climate occurs from the middle of March till the end of April, varying, naturally, between the South of England and the North of Scotland and the West Coast and the East Coast. By *late sowing* is meant the period when the average temperature in the shade is 60° F., this being in our climate from the middle of May to the middle of June.

EARLY SOWING : Parsley, radish, lettuce, cress, turnips, parsnips, carrots, beetroots, onions, spinach, peas, celery, cabbage, cauliflower.

LATE SOWING : Beans, scarlet runners, marrow, cucumber, tomatoes.

Sowing. Seeds are sown in two ways, peas, beans, carrots, and the like being sown in drills, and such seeds as cucumbers and marrows in hills. On wet land, however, it is often advisable, in order to obtain better drainage, to sow on ridges seeds usually sown in drills on the flat, this being particularly the case with such seeds as turnips. It also has another advantage—that when the time for thinning out them arrives, the operation is performed with greater perfection.

On hot, dry, sandy soils it is of the utmost importance firmly to tread in the seed. This is done after the seed has been sown, by pressing down the soil with the feet so that the moisture cannot evaporate so quickly. This answers well where the sowing is on a small scale, but is, of course, quite impracticable in the case of fields. It is quite a common practice among farmers to roll the field with a heavy roller after sowing their crops on such soil. For vegetable seeds, however, a much better plan is to use three heavy iron wheels, mounted on an axle, the distance between the wheels being regulated according to the distance that the rows are apart. The tyres of the wheels should be about three inches wide. The axle is merely a round iron bar along which the wheels may be moved, being kept in the desired position by means of an iron collar on each side, with a set-screw to keep it from slipping [4].

The question may reasonably suggest itself as to why this trouble should be taken when a heavy iron roller would cover the ground more quickly. The answer is that a great advantage is gained, as only the ground immediately over the seeds is *firmed*, or pressed. This causes the seeds to germinate more

quickly than those of weeds in the surrounding soil which has not been firmed, so that the crop is up before the weeds, thus considerably assisting hoeing. By experiments it has been proved that seeds that have been firmed in will show through the ground in from six to eight days sooner than those not so treated; and when the question of the first hoeing is considered the advantage will be readily appreciated, particularly in the case of seeds like onions and carrots. If the soil is particularly light and the season dry, it is a good plan to fill the box that has been provided on top of the wheels with sand or earth, so as to weight the firmer.

There is no need to mention here the depth at which the various seeds should be planted, nor even the exact time at which they should be sown, as it is the practice of most seedsmen to furnish instructions when they send out their seeds.

The following tables, showing the quantity of seed and the numbers of plants required for an acre, will be useful:

3. CREOSOTED BOARD DRAIN

Note that the boards on the two sides are not nailed close together; a little space is left for the water to find its way into the drain.

QUANTITY OF SEED REQUIRED TO SOW AN ACRE

Sown in Drills		*Sown in Hills*	
Beans (Dwarf)	2 bushels	Cucumber	2 to 3 lb.
Beet ..	5 to 6 lb.	Marrow ..	3 to 4 „
Carrots ..	3 to 4 „	Pumpkin ..	4 to 6 „
Cress ..	2 to 3 „	Corn (Sweet)	8 to 10 quarts
Onion ..	5 to 6 „		
Parsnips ..	4 to 6 „		
Peas ..	2 bushels	*In Beds (to be transplanted)*	
Radish ..	8 to 10 lb.	Cabbage ..	½ lb.
Sage ..	8 to 10 „	Kale ..	3 to 4 lb.
Spinach ..	10 to 12 „	Sprouts ..	3 to 4 „
Turnip ..	1 to 2 „	Tomato ..	¼ „

QUANTITY OF SEED REQUIRED FOR A GIVEN NUMBER OF PLANTS, NUMBER OF HILLS, OR LENGTH OF DRILL.

1 ounce of	Asparagus seed	is required for a	60	ft. drill
1 „	Beet	„ „	50	„
1 „	Carrot	„ „	150	„
1 „	Endive	„ „	150	„
1 „	Leek	„ „	100	„
1 „	Onion	„ „	100	„
1 „	Parsley	„ „	150	„
1 „	Parsnip	„ „	200	„
1 „	Radish	„ „	100	„
1 „	Spinach	„ „	100	„
1 „	Turnip	„ „	150	„
1 quart of	Beans (Dwarf)	„ „	100	„
1 „	Peas	„ „	100	„
1 ounce of	Cucumber	„ „	50	hills
1 „	Pumpkin	„ „	40	„
1 „	Marrow	„ „	16	„
1 ounce of	Asparagus seed	should be enough for	500	plants
1 „	Cabbage	„ „	2000	„
1 „	Cauliflower	„ „	2000	„
1 „	Celery	„ „	3000	„
1 „	Lettuce	„ „	3000	„
1 „	Rhubarb	„ „	500	„
1 „	Sage	„ „	1000	„
1 „	Tomato	„ „	1500	„
1 „	Thyme	„ „	3000	„

NUMBER OF PLANTS OR TREES REQUIRED TO PLANT AN ACRE

Distance Apart	*Number Required*	*Distance Apart*	*Number Required*
1 ft. by 1 ft. ..	43,560	6 ft. by 6 ft. ..	1,200
1½ „ 1½ „ ..	19,360	6 „ 9 „ ..	537
2 „ 2 „ ..	10,890	12 „ 12 „ ..	302
2½ „ 2½ „ ..	6,970	15 „ 15 „ ..	194
3 „ 1 „ ..	14,520	18 „ 18 „ ..	134
3 „ 2 „ ..	7,260	20 „ 20 „ ..	103
3 „ 3 „ ..	4,840	25 „ 25 „ ..	70
4 „ 4 „ ..	2,722	30 „ 30 „ ..	40
5 „ 5 „ ..	1,742	40 „ 40 „ ..	27

The Field Marker. Some method of marking out the ground for vegetables must be adopted. Nothing is more unsightly than irregular rows of vegetable crops, and if the rows are not equal distances apart much valuable space may be wasted. Some market gardeners have a very rough and-ready manner of performing this operation. There are one or two machines specially manufactured to accomplish this, but for all practical purposes the one illustrated [5] will be found to be the best. The following are some of its advantages: As it has wheels, the worker can draw it across the field more steadily. The coulters, by means of set-screws, are adjustable in more ways than one. The bar on which they are fixed with collars and set-screws allows of those coulters that are not required being turned up out of the way—a better plan than removing them altogether and possibly losing them. They can be placed close together or farther apart without any measuring, the bar on which they are fixed being marked in inches. They can be regulated as to the depth they go into the ground, as they can be set perpendicularly from the horizontal bar or at an angle. The width of the drill they make can also be regulated by adjusting the coulters. There is an adjustable marker that can be fitted into either end of the horizontal bar; this travels in the last drill made, to give the distance for the next set of drills.

When the seeds of such vegetables as celery, cabbage, and cauliflower are growing in the seed-bed, it should be the aim to raise plants of a stocky or sturdy nature. One method employed to obtain this result is to cut off the tops of the young plants, which may even be done twice before the plants are set out. It also has the added advantage that the plants do not suffer so much when transplanted.

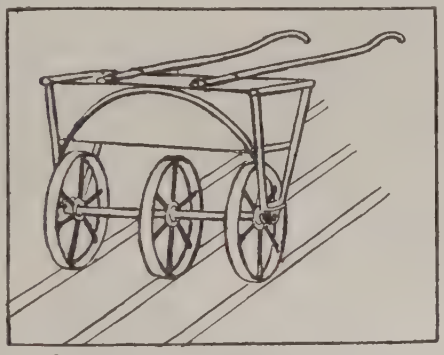
Transplanting. This is an operation that shows the advantage of the grower raising his own plants. The less time lost in removing them from the seed-bed to their permanent position the better, and it is surprising what lack of care a large number of growers show in this respect. Such factors as the condition of the soil of both the seed-bed from which the plants are to be taken and that of their new permanent home, the state of the weather at the time of transplanting, and the actual manner of transplanting all have a bearing on the success or failure of the crop.

Experience alone can give a knowledge of the condition that the plants should be in at this important stage of their life. It has been said that experience is the best teacher, though an expensive one. However, if strict attention is given to such details as keeping the seed-bed free from weeds and well cultivated, cutting the tops off the plants to keep them stocky, and, above all, if great care is exercised, in digging up the plants, to retain all the fibrous roots as far as possible and to see that the ground for their reception is moist, a great step will be taken towards counteracting any mistakes made from lack of experience. If, owing to lack of rain, the ground is short of moisture, the transplanting should be delayed as long as possible. If it must be carried out, the work should be accomplished towards the close of the day or when it is cloudy, so as to prevent as far as possible the plants from wilting. In such a case also it is more than ever important that the soil should be firmly pressed against the roots of the plants, and, if possible, a little water given to each plant to revive it.

Some people take a great deal of pains to press the soil around the plants with their hands, imagining that it is a better plan than that of pressing the soil against the plant with the dibble [6A and B]. This is bad practice, because it is aptsto leave the plant suspended [6C]; for a hole has been made with the dibble, the plant inserted, and the soil pressed with the hands probably only round the crown of the root, whereas if the dibble is inserted in the ground by the side of the plant the soil would be pressed against the whole of the roots, as well as the crown of the plants [6D]. It will be found a very good plan, when a man has completed planting a row, for him to retrace his steps, and with his feet tread the ground firmly around the roots. This applies more especially in dry weather.

In planting cabbages, lettuce, celery, and the like, it will be found economical to have a boy to go just ahead of the man who is planting, to drop the plants on the ground at even distances apart. The plants should be dripping wet when planted; the soil will then cling to the small roots, and the leaves of the plant, being wet, will be in a better condition to withstand the drying influences of the air.

In the cultivation of vegetables, it is imperative that the hoe and shove-shim be kept busily employed to keep down the weeds and to aerate the soil. Vegetables cannot be grown profitably if weeds are allowed to have sway; and the more the land is manured, the more will the weeds have a tendency to assert themselves. This is the case especially where stable manure has been used, as seed from both the hay and the corn fed to the horses is apt to fall to the floor from the manger and be swept up with the manure.



4. ROLLER FOR VEGETABLE SEEDS

Preparation and Maintenance of Hot-beds. If a grower intends raising his own plants, he must of necessity have some means of forcing, so as to have the plants ready when they are required, because in many instances this could not be done in the open air. Large growers will use forcing-houses; but as the beginner may find that one of his difficulties at the start is a lack of capital, he will find that a hot-bed will answer his purpose at less expense. A *hot-bed* consists of a raised bed of manure covered with soil, on which is placed an ordinary garden frame. The material used for preference should be horse manure, fresh from the stable, to which has been added, if available, an equal quantity of rotten leaves. Naturally, the manure and leaves must be thoroughly well mixed, and the whole should be firmly pressed down.

The various stages or operations connected with the formation of a bed of this description are as follow: A position must be chosen with a southern aspect, preferably slightly on the incline, care being taken to see that it is sheltered from cold winds and thoroughly dry. The materials to be used should be those technically known as "sweetened," a condition secured by forming them into a heap and several times turning them over and wetting them. The ground is then marked out to the size desired for the bed. It should be at least 1 ft., and, if possible, 18 in., wider all round than the frame that is to be used. It should be understood that the frames are made movable. They are made somewhat like a box, and a convenient size is 9 ft. long and 6 ft. wide, so as to take three sashes (that is, glazed tops or sliding lids) each 3 ft. in width and 6 ft. long from front to back, that being the length of the sashes. The depth of the frame itself in front should be from 15 to 18 in., and at the back 24 in. The reason for the difference between the height of the back and the front is that it causes the sashes to be on an incline, thus giving them the requisite angle for attracting the sun's rays, and allowing the rain to drain off.

In Fig. **14** it will be noticed that there are two frames of this description, on which five of the lights, or sashes, have been pushed back, the sixth being the only one actually in position, thus showing clearly the cross-pieces on which the sashes rest. Obviously, the sashes should fit as tightly as is compatible with easy working, so as to exclude the frost, and the ends of the frames should be high enough to stand above the thickness of the sashes, so that frost or cold air is prevented from penetrating.

The minimum depth of the hot-bed itself on which the frame rests should not be less than from 3 to 4 ft., and should be slightly higher at the back than at the front. The frame having been placed in position, the sashes are kept on until the heat rises to about 100° F. It will be readily appreciated that this is too high a temperature for vegetable life, and owing to the wetting of the manure before the hot-bed was made a good deal of rank steam will be given off by the fermentation. For this reason the sashes must now be removed, that this steam may be allowed to escape.

A word of warning must be given to the beginner who may be a little impatient—he will be liable to lose his first crop by planting a sowing before this excessive heat and rank steam have been given off. This process often takes three or four days. The temperature should never exceed 90° Fahrenheit.

The surface of the manure on the hot-bed should be covered with about one barrow-load of good loamy soil to each division of the frame, care being taken to see that it is of even thickness over all the manure. The sashes should then be replaced. Having sown the seed or planted the plants, great care must be taken to maintain an even temperature. This is accomplished by placing mats over the frame at night and on windy, wet days. It may be found necessary, to maintain the temperature, to add coatings of fresh manure, known as "linings," which are piled up round the bed on all sides. The temperature of the hot-bed should be maintained at an average of 75° F., and immediately it falls below this old linings should be taken out and replaced with fresh ones.

Cold Frames and Their Uses. Cold frames consist simply of two boards running parallel and nailed to corner posts to keep them in position. Spare sashes or lights are used as a top covering. The back board need not be more than 10 in. to 1 ft. in height, and 7 in. will be sufficiently high for the front board. As with the frames used on hot-beds, this difference in height between the front and back boards is in order to have the sashes or lights on an incline. The length

of these cold frames is of little importance, provided that they are in multiples of 3 ft., which is the width of a sash. It is a matter of some importance that they should be sheltered from the north-west, and if the position is not naturally protected a fence about 6 ft. high should be erected. The aspect of the sashes should be south, or at least south-east. The ground space under each sash being 3 ft. by 6 ft. will be sufficient to hold about 500 cabbage or cauliflower plants or 800 lettuce plants. As these plants belong to the hardy class, they will be uninjured except by very severe frosts. They must, nevertheless, be treated as naturally as possible. To do this, the sashes should not be put over the young plants—which would be planted in the frames during October—until severe weather arrives, usually about a month or six weeks later. Should a sharp spell set in, the sashes may be placed on the frames, but care must be taken to remove them as soon as the cold snap breaks up, so as to harden the plants for the winter. During severe winter weather the sashes will have to be replaced; but even though the temperature drop from 5° to 10° below freezing point, they must be raised at the back for an hour or so during the day, so as thoroughly to air the frames. This can be done by placing a brick or block of wood under the sash at the top.

Another use to which sashes can be put is to fill spare frames with straw or leaves, which will keep the ground moist and protect it from frost, so that at the end of February the lettuce plants that have been in the frame all the winter can be thinned out and transplanted to the spare frames. This will naturally give them a check, and if the nights were cold or frosty they would certainly perish, but, protected for a time with the sashes, properly aired, and the sashes opened when rain falls, so that they may be thoroughly watered, they will be ready for market in about six weeks, and should fetch a high price.

Spare frames can also be used for planting seeds of hardy vegetables, or even cucumbers, utilising the spare sashes to protect them, and in a measure to assist their growth.

Protecting Cloth Instead of Sashes. Many a market gardener has saved a good deal of money by using cloth for covering his cold frames instead of using the glazed sashes. It will readily be seen that this method, though cheaper in the original cost, requires more labour. The lighter the material is in colour, the better the light will penetrate. As light is one of the hardening agencies, it will mean that the cloth must only be placed over the frames when the weather is very severe, for if light and air are both excluded the plants will not be hardened, but, on the contrary, will be weak and susceptible even to slight frosts. Some growers use matting over their sashes as an added protection in very severe weather, but if the plants have been gradually hardened this should not be necessary, and in a large number of cases it has done more harm than good, because it has been left on too long, and has therefore excluded too much light. This does not apply to hot-beds, which, as we have seen, are very different from cold frames.

Chemicals and Vegetable Crops. The question of soils and their mineral constituents has been already dealt with; and as certain soils require certain chemicals that others do not need, so, with vegetables, some require chemicals of a very different nature from others.

Vegetables may roughly be divided into two classes: (1) Those in which phosphates and potash very largely predominate, and (2) those in which sulphur, soda, and salt are also found to a considerable extent. The following table shows approximately the proportions in each, and is based on the average amounts remaining in the form of ashes after a sample has been burnt.

Vegetable.	Phosphates	Potash	Soda	Salt	Lime	Sulphuric Acid
Class I.:	Per cent.	Per cent.	Per cent	Per cent.	Per cent.	Per cent.
Pea	36	40	—	—	—	—
Bean	30	40	—	—	—	—
Potato (tubers only)	19	59	2	—	2	6
Parsnip	18	36	—	5	11	—
Carrot	12	36	—	—	—	6
Jerusalem artichoke	16	65	—	—	—	—
Class II.:						
Cabbage	16	48	4	—	15	8
Turnip	13	39	—	10	10	14
Beet	14	49	9	20	6	5

Lentils belong to the first class, while broccoli, cauliflower, and kale belong to the second class.

This table shows roughly what chemicals the different vegetables require for their proper nourishment. Clayey and loamy soils in most cases contain an abundance of potash and phosphates; hence, if it is desired to grow vegetables mentioned in Class II., the other ingredients must be added. In sandy soils, however, phosphates and alkalies are lacking; therefore it follows that, instead of using manure which can be more profitably employed upon loamy soils, it will be found that a mixture of kainite, which is a form of potash, and superphosphates of lime will yield better results. Particularly is this the case with crops like potatoes, onions, and carrots, which favour sandy soils. Sulphate of ammonia can be mixed with superphosphates, and for that matter with any acid manures, but never mix either of them with basic slag or nitrate of soda, for ammonia may be given off as a gas.

Asparagus. Most of our common vegetables are annuals, but there are some perennials, of which asparagus is one. The usual practice is to grow it from seed. This is easily obtained from existing beds, as it yields abundant seed in the autumn. The method of harvesting the seed is to wait until the berries are quite ripe, which is when they are a deep red in colour, and then to hang them up to dry. They should next be rubbed out through a sieve so that the pulp passes through the sieve, leaving the seed behind. The seed-bed must be carefully prepared by deep digging, followed by a moderate dressing of well-rotted manure. It is a mistake to make the seed-bed too rich; it can always be improved by a top dressing in succeeding years. The seed should be sown in April or May, in rows one foot apart, and it is of the utmost importance that the young plants be kept well hoed and free from weeds. If a bed is neglected it may take two years to raise as large plants as might be grown in one year.

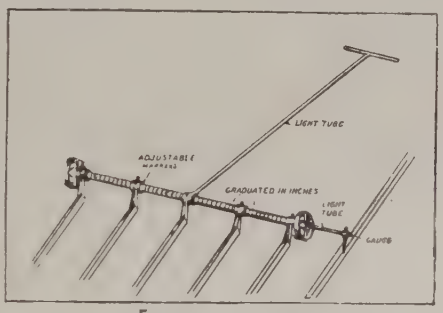
The first year the plants will make very little top growth, as the roots develop first. The permanent bed is made in September, and one of the best forms of beds is five feet wide, with three rows of plants—one row down the centre of the bed, with a row on either side. The outside rows should be

12 in. from the edges of the beds, leaving 18 in. between the centre row and those on the outside. The plants should be 9 in. apart in the rows, and the crown of the root should be covered with about 3 in. of soil. It is a very good plan to rake over the bed a week or so after planting, so as to destroy any weeds that may have germinated.

Asparagus will be found to benefit greatly by an application of salt—1 lb. to 5 sq. yds.; and a top dressing of manure should be given every spring, during the month of March. Whatever other vegetables may succeed with weeds, asparagus will not; it cannot possibly be made to pay if weeds are allowed to grow. The beds should always be thoroughly cleaned before the winter.

Globe Artichoke. There are two kinds of artichokes, the globe artichoke and the Jerusalem artichoke. The former is really the true artichoke. It is a most accommodating plant, and it has been said of it that it can be treated as an annual, biennial, or perennial, but it is as a perennial that it is chiefly grown. It can be grown from seed in a rich, moist soil, and is one of those plants that greatly benefit by saline manures. After plants have been grown from seed they can easily be increased by suckers, but a bed, having once been established, will remain in bearing for several years.

The portion of the plant which is used as a vegetable is that of the undeveloped flower-heads, which are boiled. Artichoke chard is another form of it. If the plant is cut down to about a foot from the ground early in July, about September a great deal of young growth will have been made, and this young growth is then tied moderately close together and the soil banked up so as to exclude the air, whereby the shoots are blanched.



5. FIELD MARKER

Jerusalem Artichoke. This is entirely different from the globe. In fact, it belongs to another tribe altogether, and perhaps the only reason that it is called an artichoke is because it resembles its namesake in flavour. Its appearance in growth is very similar to the sunflower, to which tribe it belongs. In this case it is the roots or tubers which are eaten. They resemble knotted potatoes. It is quite hardy, and can be dug in November. As a vegetable it is not to be despised, as its nutritive value is equal to that of the potato, which its culture in all respects resembles. Strange to say, it appears to be absolutely immune from disease, and will grow in almost any soil. In certain districts it is grown for the pigs, who root it up for themselves.

Broad Bean. This is one of the hardiest plants of the kitchen garden, and, like peas, can be sown in October where the soil and situation are favourable. A succession can be sown in January, but for the main sowing it would be better to wait until March. Broad beans should be sown in rows about 4 ft. apart, which leaves room for a row of spinach or lettuce in between. There are three classes—the Mazagan, the Longpods, and the Windsors. The first-named are generally sown in the late autumn, the second early in the year, and the last as late as from April to the end of May.

Dwarf or French Kidney Beans. These prefer a good but light soil. The best time to sow is towards the end of April, from which time a succession of sowings may be made until the end of July. One point to remember is that they should not be overcrowded, which is a very common error to be guarded against. They should be planted in rows 2 ft. apart, and care should be taken in their gathering to see that none are left, for they will soon cease to bear if any are allowed to run to seed.

Runner Beans. With the exception that these require more room, their cultivation is the same as for the dwarf. They are planted in single rows, which should be 5 ft. apart, but it is a common practice to grow them in double rows. In this case there should be 9 in. between the two rows, the double rows themselves being 6 or 7 ft. apart.

Beetroot. March should not be allowed to pass without making the first sowings of beet. This is sown in drills 15 in. apart. Care should be taken to tread the soil firmly. They are thinned out from 9 to 12 in. apart. In this operation it is not of so much importance to leave the strongest plants as to leave those that have the best colour, and it is essential that the work should be carried out as soon as possible. In digging up the roots it is vital that they should not be broken, or they will bleed, and their appearance will be spoiled for salad.

By September some of the roots will be ready for lifting, and they should all be dug before November. It is possible to leave them in the ground through the winter, provided that they are covered with litter, but it is not advisable to do so unless absolutely necessary, as they are apt to be injured by frost if the weather is very severe.

Broccoli. It is a wonder that this vegetable, which is so closely allied to cauliflower, should ever have been separated from it. Cauliflower, it is true, is generally planted for summer use, and broccoli for use in the autumn, but there is no reason why one should not do as well as the other in either spring, summer, autumn, or winter.

The grower will soon find that if he intends to cultivate broccoli successfully his land must be in a good state of fertility, as is the case with nearly all the cabbage tribe. Sow the seed on carefully prepared beds; and when the plants are large enough to set out in the field have 2 ft. between the rows and from 18 in. to 2 ft. between the plants in the rows. Thinning and planting out must not be neglected, or the plants will be spoiled.

Autumn Broccoli. The seed of this should be sown in frames in February and March, and in the open in April.

Winter Broccoli. This should be sown during April, but care should be taken that it is not left too late. The seasons vary so much that due allowance must be made for the fact. Do not hesitate to plant out as soon as possible, for although to a certain extent it does not interfere with the time that they will be ready for cutting, yet it does influence the size of the heads.

Spring Broccoli. Broccoli being easily affected by climatic conditions, there is no certainty with the spring variety. Warm spells of sunshine may tempt it forward, late sorts thereby being ready for market before they were expected. The seed for this

should be sown in April and May, and it is always advisable to make at least three sowings, the most important being made in April.

Summer Broccoli. Many growers feel that this class need protection during the winter, but experience shows that, in nine cases out of ten, it is better to let them take care of themselves, and certainly the best crops are obtained when they have been left undisturbed. Perhaps one of the greatest advantages of summer broccoli is that it comes in just before peas, and as a consequence is always welcome in the markets, particularly as it is generally well over before the bulk of the peas are on sale. The seed is sown in May, for the heads to be ready to cut in the June of the following year.

Sprouting Broccoli. Perhaps of all the vegetables most welcome in the winter and early spring sprouting broccoli will rank first; it is a favourite with growers, because it is easily grown, is very hardy, stands the winter well, and is exceptionally free from injurious insect pests.

Brussels Sprouts. March is really the month for sowing these, although a succession might be sown in April for late supplies. To obtain perfection they should be sown early, so as to give them a long time for developing. The plants should be ready for transplanting in from eight to ten weeks from sowing the seed, and the plants are set out at about 20 in. apart. The soil that suits them best is a stiff, rich loam, and, as with other plants of this nature, they should be constantly hoed.

Cabbages or Brassicæ. These really include the ordinary cabbage, Brussels sprouts, savoys, red cabbage, borecole, curly kale, broccoli, and cauliflower, and their treatment, both as regards raising the seed and their after-cultivation, is very similar. The seed-sowing times are in April for summer use; June and July for autumn and winter use; August and September for spring use. Never have a seed-bed near trees or hedges, but as much in the open as possible [9]; and care must be taken to see that not only the seed-bed but their permanent home also is well drained. The seed should be covered with sifted soil and well trodden in.

As soon as the seed comes through, it will require constant attention to keep the bed free from weeds, and, if the weather should be dry, to be ever ready with the watering-can to keep it moist. Give it a good soaking, and not simply a sprinkling—this will tend to make the plants sturdy. The seed-bed will profit by an application of lime, salt, or soot, which will not only help the growth of the plants, but prevent attacks by injurious insects. The process of thinning them out should be attended to as soon as the plants are large enough to handle.

Red Cabbage. This is generally only grown for pickling purposes; its cultivation is easy, being the same as for the ordinary cabbage. As soon as the head is thoroughly formed it will be ready for cutting.

Savoy Cabbage. The curly green leaves of this variety of cabbage are very attractive, and it is noted for its leaves and close head, and is useful for growing between rows of peas.

Curly Kale, Borecole. There are several varieties of this, and it is sometimes spoken of as "sprouts," on account of the curly sprouts which grow up the stem. Some varieties are green in appearance, while others are purple. They are tall in growth, and require more space than ordinary cabbage, being planted from 2 to 3 ft. apart, according to the variety.

Cauliflower. The cultivation of cauliflower is almost identical with that of broccoli and cabbage, and is certainly one of our favourite English vegetables, the delicate white head being the attraction. Its head is more compact and the stem shorter than that of broccoli [10].

Carrots. Carrots are not only grown for our markets, but there is also a large tonnage grown for the feeding of horses and cattle. Again the importance of keeping the ground free from weeds must be emphasised, as in their early life carrots are of comparatively feeble growth, and a great injury will result in respect of the yield per acre if this matter is not attended to.

The most general method is to plant them in drills 14 or 15 in. apart, and to thin them out to 3 or 4 in. in the rows, though some growers prefer to sow them broadcast. A deep, light soil with chalky tendency suits them best, and the seed should be sown as shallow as possible, the land being treaded afterwards to make it firm. A calm day should be selected for sowing the seed, as it is very light and apt to be blown about if it is windy.

The earlier varieties may be sown in February, a sheltered position being selected, and the main crop about the end of March. The seed takes from a fortnight to three weeks to germinate. They should be thinned as soon as possible, and the soil frequently hoed to keep it loose. If the carrots are required for storing it is advisable to leave them in the ground until the end of October, or even the early part of November.

Celery. This is one of the crops that should be in favour with all small-holders and market-gardeners, as it brings in a return at a time of year when there is not much else coming into the exchequer, but failure will inevitably result if its cultivation is undertaken lightly; and unless the grower can afford to feed the ground well he had better leave it alone altogether. February is the month for making the first sowing, which is followed by successive sowings up to May. The first is made in a gentle heat, and the latter in a warm, sheltered position outside. Celery requires a rich, deep soil and cool, moist atmosphere.

As soon as the plants are large enough they should be transplanted to a cold frame or shallow trenches. The ground of their permanent position must be carefully prepared. First of all, it must be trenched and well manured. Just before the plants are ready for planting out, a trench should be dug to a depth of from 12 to 18 in., the soil thrown out being laid in a ridge on either side and a layer of well-rotted stable manure being placed in the bottom. Early in July the plants are set in the bottom of the trench about 6 in. apart, and, if possible, it is well to water them for a night or two, until the plants begin to grow, which will usually be in two or three days. This is still more important if the weather is dry.

There is very little to do after celery is once planted except to keep the ground free from weeds for six or seven weeks. About the middle of August it will be found necessary to begin earthing up—that is, filling in the trench with the soil that has been thrown out, and gradually, as the plants grow, banking them up on either side with earth. This operation is to blanch or whiten them, and will have to be continued about every week or ten days until the earth is banked up nearly to the top of the plants, so as to keep the leaves upright and prevent them from spreading. With the coming of September the first sowings should be ready for market [11].

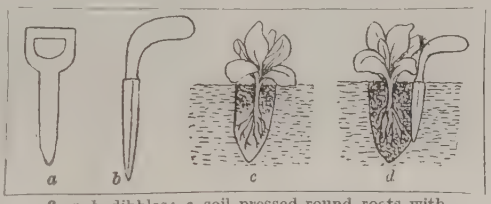
Cucumbers. There is a very general impression that cucumbers cannot be grown successfully out of doors, but this is a great mistake, for although the outdoor varieties are not of such good appearance, and are smaller than the indoor varieties, they are quite equal to them in flavour. Only those varieties known as "Ridge" cucumbers are suitable for growing in the open, and are useless for exhibition purposes.

They are grown on hills or ridges. The best method is to throw up a ridge with the plough, having previously given the land a liberal dressing of manure. The seed can be sown directly on these ridges, but if a cold frame or hot-bed is available it will pay to raise the plants by this means and then transplant to the ridges. They are ready for moving as soon as they have obtained two or three of their rough leaves, which is usually about three weeks after sowing. Sow about the middle of May.

It will be found of great benefit to the young cucumber plants if a row of runner beans are planted on either side of them to act as a shelter from the cold winds. Cucumbers can be grown on hot-beds or under grass all the year round, but a temperature of between 70° and 75° F. must be maintained. To obtain any fruit from cucumber plants grown under glass, the flowers will have to be fertilised by hand, particularly during the winter. In the open air this work is performed by insects, the wind, and rain.

Gherkins. These are a small variety of cucumber which are used exclusively for pickling. They are only 2 or 3 in. in length, of strong growth, and should be planted 5 ft. apart.

Horseradish. There is generally a good demand for this root; it is easily grown, and without much expense or labour. The best method of propagating it is to obtain some old roots and cut off the smaller rootlets or side shoots; these rootlets should be cut into lengths about 4 in. long, the top end being cut square, and the lower end slanting—this will prevent it being planted upside down. If planted the wrong way up, it would grow, but would not make such a good root.



6. *a*, *b*, dibbles; *c*, soil pressed round roots with hands (wrong method); *d*, soil pressed against roots with dibble (right method).

The soil should be prepared before the winter by being deeply trenched. Holes should then be made with a dibble, about 1 ft. deep and 1 ft. apart in the rows, the rows themselves being 2 ft. apart. Insert the rootlet, or *set*, as it is termed, when it has been prepared in the manner indicated, taking care that the set is at least 2 or 3 in. below the surface. Press the soil well into the hole. It is a hardy plant, and one of the last to be dug before the winter.

It is prepared for market by cutting off the green tops and washing the roots, removing all the smaller rootlets which are used as sets for another crop.

Leeks. These vegetables [8] are grown almost exclusively as a second crop. A light, rich soil will be found to suit them best; in fact, the soil can scarcely be too rich, and in moist land they will grow to a great size.

April is the month for sowing the seed, which is sown in drills about 12 in. apart. As soon as practicable, they are thinned out to 5 or 6 in. apart in the rows. As soon as the first crop has been gathered, which is usually about July, the ground must be thoroughly prepared by ploughing and harrowing, and the leeks set out as in the seed-bed, 12 in. between the rows and 6 in. apart in the rows. As the plants grow they are earthed up in much the same manner as celery, in order to blanch them. They are hardy vegetables; 20 to 25 deg. below freezing will not injure them.

Lettuce. This is easily grown, and as a rule is less troubled by insect pests than almost any other of our green crops. It may be divided into two classes—(1) the cabbage, or low, round-hearted variety; and (2) the Cos, or tall, upright form.

Lettuces require a loose, rich loam, and manure must not be stinted. The seed should be sown in drills 12 in. apart, and, while the plants are quite small, thin them out to 2 in. apart. Later, thin them out again to about 6 or 8 in. apart. Sow the seed thinly and transplant those pulled up in the thinning. Begin sowing in February with monthly sowings up to July, for cutting in the spring and summer, but for winter and early spring cutting the seed should be sown in August and September.

The Cos variety is of very little service for winter cutting, as the plants are apt to rot off when tied up. This is the usual practice resorted to by growers in order to give them crisp, white hearts. It is a simple operation, consisting in tying a piece of bast round the centre. Care should be taken not to tie them up more than two or three days before they are required for market, as it causes them to run to seed. This attention is not required in the case of the cabbage variety, which, being more hardy, are better suited for winter cutting.

Marrows. These are very susceptible to cold, and the young plants in particular like a warm situation. A rich soil is also required; otherwise their cultivation is simple. The seeds are sown in pots or frames during April or early in May, and transplanted when they have four leaves, planting them out early in June. The seed may be sown in the open towards the end of May or beginning of June. It is advisable to peg down the bines at a joint, from which they will strike root and thereby add vigour to the plants.

Onions. The simplest method with regard to onions is to grow them from seed, though they are grown from *sets* as well. The seed is sown in drills 9 in. apart and ½ in. deep during February and March, but for a supply in winter and the following spring the seed should be sown in the early part of September. The silver-skinned variety, which are used for pickling, are sown towards the end of April or beginning of May, and should be grown in poor soil. The other varieties, however, require a well-manured soil, and it is very essential that the soil should be well pulverised and rolled flat.

The practice of firming the soil after sowing is very impotant with this crop, as when the seed first pushes its way through the soil it is very difficult to see if any weeds have been allowed to grow.

Parsnips. The end of February should see the first sowings of this seed, with sowings for the main crop in March, and they naturally require a deep soil, so that their roots can push down into the ground without any trouble. The seed is sown in shallow drills 18 in. apart. Land that has been well manured for a previous crop suits them best,

as they have a tendency to produce forked roots on freshly manured soil. They are thinned out to 9 in. apart in the rows.

Peas. Peas prefer a warm, light soil, not too generously manured. The seed should be sown fairly thickly, as mice are apt to steal them out of the ground. The usual practice is to sow the seed in drills about 2 in. deep, the drill being 4 in. wide. The distance between the rows varies according to the height to which they grow, but with the dwarf varieties the rows are generally about 2 ft. apart, while with the taller kinds the rows are generally from 4 to 6ft. apart. In the latter cases it will be found more economical to plant such things as lettuce, radish, spinach, or even vegetable marrows between the rows.

Birds are great depredators of peas as they begin to shoot, and a very good plan to prevent loss in this manner is to stretch black cotton along the rows.

Potatoes. These form by far the largest crop of a kitchen garden. [See page 705.]

They are propagated by *sets*, or *seed* potatoes, which are really medium-sized potatoes that are clean and healthy. They are planted in deep drills or furrows, about 4 in. deep, the rows being about 3 ft. apart, and the sets 10 or 12 in. apart in the rows. A noticeable feature about early potatoes is that they germinate and ripen quickly, but do not keep so long, and their chief use is to give a supply until the main crop is ready to dig. Some people dibble in the seed, but it is not to be recommended, and should positively be avoided on clay soils, for the looser the soil the better it will suit the potatoes. As soon as the shoots are 4 or 5 in. above the ground, they should be hoed, the soil between the rows dug over, and some of it drawn up against the plants. A plough run up between the rows will effect the same result. When they have grown eight or more inches high, this operation should be repeated.

Radish. The radish is what might be termed catch or auxiliary crop, scarcely interfering with a the main crops at all. For instance, it can be sown between rows of peas or on the sides of celery trenches. There is always a large and ready market for radishes, though the work of tying them into bunches requires a good deal of labour.

As with most crops, the earlier that they are placed on the market the better the price will be. To obtain them early, a light, rich soil will be required. Heavy soils should be avoided, as they only produce an inferior article. They can be sown broadcast or in shallow drills, these being from 4 to 6 in. apart, according to the variety, the long radishes or small turnip sorts not requiring so much room. It is a great mistake to sow them too thickly, as the roots will then be small, hard, and stringy.

The first sowings may be made in the latter part of January, but all early sowings should be protected from frost by litter, as if they do not grow quickly, or if they receive a check, they will be hot and tough. Successive sowings may follow. The Black Spanish or winter variety are sown in July.

Rhubarb. Easily cultivated and requiring little attention, rhubarb is propagated by dividing old roots either in the autumn or early spring—the former for preference. It is obvious for a plan of this nature that the ground should be well trenched and manured.

The plants are set about 4 ft. apart, and should be well watered for a day or two after planting. Rhubarb should never be pulled the same season that the roots were planted, as this spoils both the colour and the flavour. To obtain an early supply, the roots should be covered with litter and large pots—grape-barrels, which can be obtained from any greengrocer, being most useful.

Shallots. This vegetable is well known as a substitute for onions, but it may not be well known that when well cultivated the clumps grow bigger than a man's fist, and the individual bulbs will be as big as a chestnut. Here again is another instance of propagating by division, the bulbs being separated from the clump and planted in rows about 9 in. apart, September being the most suitable time to plant them, as they take a long time to grow. They make but slight growth before the winter, but develop rapidly with the opening of spring. They should be pressed firmly into the soil, but not buried. One great advantage of shallots is that, being hardy, they are ready for market at least three weeks before onions. They are very prolific.

Spinach. This is a very important crop for market gardeners, requiring but little culture, and is what might be termed an all-seasons vegetable. It can be sown in early spring as an auxiliary crop between rows of cabbage, peas, or beans, and under suitable conditions is ready for cutting in four or five weeks. The first sowings should be made early in September, so that it has obtained a hold before the winter sets in; this gives a vigorous early crop in spring. The seed should be sown in drills about 1 ft. apart.

At the end of January or early in February more sowings should be made. The seed should be sown thickly, using from 10 to 15 lb. per acre. The frost may cut some of it, and, if not, the extra crop dug in as a manure will always be found to be profitable. It requires a light, rich soil that has been well drained and well manured. The prickly seeded variety is sown in the autumn and the round seeded varieties in the spring. The leaves should be cut as soon as they attain a fair size, as they soon run to seed. It is most important to keep the ground free from weeds.

Tomatoes. To grow these with any degree of success out of doors, a hot, dry summer is required, plenty of sunshine and a good circulation of warm, dry air being essential. The seed is sown in pots in February under glass with the temperature at from 60° to 65° F., and the young plants require hardening off late in May for planting outside. They should not be transplanted into the open, however, before the beginning of June. The best method is to plant them in rows 4 ft. apart, and the plants themselves from 2 to 3 ft. apart in the rows.

During the fruiting season they require a plentiful supply of water at their roots, and the surface of the soil should always be kept well pulverised and free from weeds. As soon as the plants have been planted in the position that they are to occupy permanently they should be staked, care being taken to see that the stake is driven firmly into the ground. The stakes should be from 5 to 6 ft. long, according to the nature of the soil, 4 ft. being above ground and about 2 ft. in the ground. On a stiff, heavy soil from 12 to 18 in. will be found sufficient for the stake to be in the ground.

Regular attention should be paid to the tying; and as soon as the early flowers have set, the main stem should be topped—that is, the top pinched out of the head and the side fruiting branches kept short beyond the fruit.

Turnips. A well-manured, deep, sandy soil will be found the best for turnips. They can be sown from March to July in shallow drills, but for pulling

GROWING VEGETABLES FOR THE MARKET

7. A GOOD CROP OF SAGE

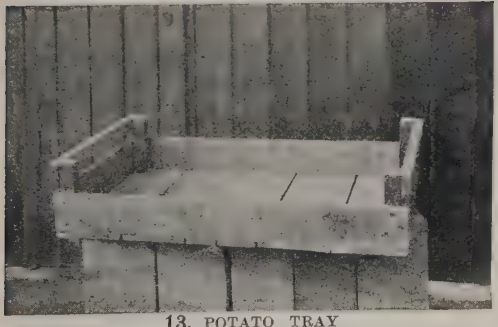
8. A FINE FIELD OF LEEKS

9. SPRING CABBAGE READY FOR PLANTING OUT ON A NEARLY CLEARED AUTUMN BROCCOLI FIELD

10. CAULIFLOWERS GROWN BETWEEN ROWS OF CELERY

11. CELERY FOR THE LONDON MARKET

12. POTATO TRAYS STACKED AND THATCHED



13. POTATO TRAY

14. FRAMES FOR RAISING VEGETABLES

The photographs on this page are by courtesy of Messrs. Chivers and Sons, Limited, Histon

in winter and spring the seed should be sown during August. One of the greatest favourites as a substitute for greens in the spring are the young tops of the turnip. They are not a difficult crop to grow, but they must grow quickly; and to assist them they should have a dressing of lime in one form or another. Old plaster or mortar from building refuse will be found useful for digging into the soil in preparing it for the crop. They need thinning in good time—in fact, almost as soon as their first rough leaves appear. [See page 704.]

Herbs. As no kitchen garden is complete without an assortment of herbs, a few notes on their cultivation will be found useful.

Balm. This herb is a perennial, and can be grown from cuttings. At the same time, it may also be treated as an annual, and grown from seed, the seed being sown during May.

Sweet Basil. An annual, and one of the most popular herbs for flavouring purposes. It can be sown in the open ground in April, being planted in rows about a foot apart, and the plants should be thinned out to 8 in. apart.

Bush Basil. The treatment for this herb is the same as for Sweet Basil, the difference being that it is a dwarf-growing variety, and hardier.

Marjoram. This is a great favourite in all kitchens. It is generally sown about the beginning of April, the plants requiring to be a foot apart in the rows and between the rows. Like balm, it is, strictly speaking, a perennial, but can be grown as an annual. It is used in the green and the dried states.

Mint. This is sometimes spoken of as pea-mint or spearmint, which distinguishes it from peppermint. It is propagated by division, and should be planted in damp soil, in rows a foot apart. The runners should be kept cut back, or else it will run all over the ground; and it is advisable to make a fresh bed every two or three years, or else plough it in very shallow, otherwise the leaves are apt to become wiry and small.

Peppermint. The cultivation of this is the same as for spearmint.

Parsley. This herb requires plenty of room, and also a rich, damp soil, to grow to perfection. The seed can be sown any time from February to July. It can be sown as a border or in a bed in rows a foot apart, thinning out from 4 to 6 in. It should not be allowed to run to seed, and to prevent this it should be kept cut over.

Sage. This can be grown from seed sown in the open ground during April and May, and, like most herbs, it is best sown in rows, the plants being thinned out to 6 in. apart [7].

Summer Savory. Another useful herb for flavouring purposes. It is an annual, and grown from seed sown in drills a foot apart during April, the plants being thinned out to 6 in. apart.

Common Thyme. This is another of our English aromatic herbs, and a great favourite in all gardens and kitchens. The seed is sown in April, and the plants make a very effective border. It can be grown from seed or by division.

Lemon Thyme. This plant can only be propagated by division. It is aromatic, and always finds a ready sale. It should be planted in rows a foot apart, leaving 6 in. between the plants in the rows and, like most herbs, prefers a damp, rich soil.

Work Among the Vegetables Month by Month. Below we give a programme of the work to be carried out during each month:

January.—The ground as far as practicable should be thoroughly dug over and trenched. Early peas and broad beans may be sown in sheltered positions. If there is a spare frame, early ash-leaved potatoes should be planted.

February.—Any ground that has not already been dug should be attended to as soon as the weather allows, and towards the end of the month early potatoes may be planted in the open. Any warm spots and sheltered corners may be sown with early crops.

March.—This is the first month for sowing in earnest, and the main crops of the following may be sown: Peas, beans, onions, carrots, spinach, cabbage, radishes, and the like. The young plants in the frames need attention, and should be thinned out and horseradish planted.

April.—The hoe and shove-shim must be busy keeping down the young weeds as they grow. Seed-beds should be carefully watched, and, if the weather is dry, must be watered. Sowing and planting must be attended to, and young cabbage and lettuce plants may be ready for transplanting. Globe artichoke suckers should be planted, and asparagus beds receive a dressing. No time should be lost in sowing seeds or in obtaining plants. Herb seeds will do better if sown this month than almost at any other time.

May.—This is the month for dividing rhubarb roots for making a fresh bed. Tall-growing varieties of peas must be staked, and others sown. Onions, carrots, parsnips, and the like should be thinned out. Lettuce of the Cos variety should be tied up, to give them good hearts. Early potatoes will be ready for earthing up, and it would be well to bend the outer leaves of cauliflowers over the heads as they appear, to keep them white. The main crop of beet should be sown in the earlier part of the month. Dandelion, which is such a welcome addition to the salad-bowl, should be planted now.

June.—We look to this month for some of the first fruits of our labours, such as early potatoes, carrots, peas, cauliflowers, and even beans. There is still time to sow peas and beans, and the earthing up of potatoes should be continued. Cucumbers for pickling, lettuce, cabbage, and the like, should be sown; these will be of great value for planting out when the summer crops have been gathered. Every advantage should be taken of showers for planting out broccoli, lettuce, cauliflower, as well as celery.

July.—Vacant ground should now be prepared for autumn and winter crops. A few dwarf and runner beans can be sown, but it is not advisable to sow many, as they may be cut with the frost just as they are coming into bearing. Radish, turnip, lettuce, prickly seeded spinach, and parsley seed for winter crops should be sown, and more celery, leeks, and broccoli planted out. Early potatoes will be ready, and should be taken up to make room for autumn and winter crops.

August.—Give a liberal dressing of lime among cabbage, etc., to kill slugs and caterpillars. Earth up leeks and celery; cut down the stems of gathered artichokes; hoe and thin out turnips; take up and lay out to dry onions as soon as the tops begin to wither. Plant out sprouting broccoli, savoys, curly kale, and Brussels sprouts; sow Welsh and Spanish onions, cabbage, cauliflower, and parsley for next year's crop. Lettuce and turnip may still be sown in the earlier part of the month, and the celery should continue to be earthed up, but care must be taken that the soil does not get into the heart. Second early potatoes will be ready, and need digging.

September.—Plant out cauliflowers, cabbage, broccoli, and the like, and dig up first sowings of

FROM MARKET GARDEN TO CITY MART

LOADING UP FOR A MIDNIGHT JOURNEY TO TOWN

A BUSY SCENE AT COVENT GARDEN MARKET

main crop potatoes, continuing to earth up celery as required; it takes from five to six weeks to blanch celery properly. Thin out the vegetables sown last month.

OCTOBER.—Take up carrots, parsnips, beetroots, turnips, and the remainder of potatoes, and winter greens should be transplanted. Cabbages and savoys should be earthed up to the first leaves.

NOVEMBER.—Trench and ridge unoccupied ground and cover with manure. Peas and beans may be sown in sheltered places for the following year. Burn all rubbish such as bean and pea vines, potato tops, and the general rubbish connected with vegetables. Asparagus beds should be thoroughly cleaned, and celery will be ready for digging, and also horseradish that is required for storing through the winter.

DECEMBER.—With this month we expect frosts, and as soon as the ground is hard seize the opportunity to wheel out manure. When the weather is open and fine, continue to trench and ridge, that the frost may do its work and the land receive the full benefit of this great help in pulverising the soil. Avoid working on the land when it is sodden with wet, as it is liable to do more harm than good, particularly on some heavy soils.

The Choice of Seeds. Here is a list of the best kinds of the various vegetables and the order in which they should be sown:

ARTICHOKE. *Plants:* Green Globe, Purple Globe. *Tubers:* Sutton's White Jerusalem.

ASPARAGUS. True Giant, Connover's Colossal, Argenteuil.

BEANS. *Broad:* Sutton's Mammoth Longpod, Bunyard's Longpod, Exhibition Longpod, Green Longpod, Sutton's Green Windsor. *Climbing French:* Sutton's Earliest of All, Tender and True, Epicure. *Dwarf:* Sutton's Superlative, Canadian Wonder, Ne Plus Ultra, Negro. *Runner:* Sutton's Prizewinner, Mammoth White, Best of All, Scarlet.

BEETROOT. Sutton's Blood Red, Cheltenham Green Top, Dell's Dark Red, Dell's Black.

BROCCOLI. *First Division* (sow in April and May for cutting in September, October, and November): Michaelmas White, Veitch's Self-protecting, Walcheren, White Sprouting. *Second Division* (sow in May and June for cutting in the following January and February): Early White, Penzance Early White, Winter Mammoth, Snow's Winter White. *Third Division* (sow in March and April for cutting in March and April the following year): Perfection, Purple Sprouting, Leamington, Knight's Protecting. *Fourth Division* (sow in May and June for cutting in May and June the following year): Late Queen, Sutton's Latest of All, Methven's June.

BRUSSELS SPROUTS: Sutton's Exhibition, Daniel's Colossal, Dalkeith, Imported.

CABBAGE. *First Division* (for spring sowing): Daniel's Defiance, Enfield Market, Improved Nonpareil, Rosette Colewort, Christmas Drumhead, Winningstadt. *Second Division* (for August sowing): Ellam's Early Dwarf, Offenham, Sutton's Harbinger. *Savoy:* Sutton's Earliest of All, Dwarf Ulm, Tom Thumb, Ormskirk. *Pickling:* Large Blood Red, Giant Red Drumhead.

CARROT. *Stump-rooted Varieties:* New Early Forcing Horn, Early French Nantes, Early Scarlet Horn. *Long Varieties:* Altrincham, Red St. Valery, Long Red Surrey, Sutton's New Red Intermediate, Sutton's Scarlet Intermediate.

CAULIFLOWER: Veitch's Autumn Giant, Walcheren, King of Cauliflowers, Early London White, Eclipse, Snowball.

CELERY. *White Varieties:* Sandringham Dwarf, Sutton's White Gem, Daniel's Giant White, Silver Plume. *Red Varieties:* Standard Bearer, Leicester Red, Laing's Mammoth Red, Sutton's Dwarf Red.

CUCUMBERS. *Frame Varieties:* Lord Roberts, Improved Telegraph, Tender and True, Lockie's Perfection, Rochford's Market, Duke of Edinburgh. *Ridge or Open-air Varieties:* Stockwood, Japanese Climbing, Sutton's Long Green, Daniel's Perfection Ridge. *Pickling Varieties:* Short's Prickly or Gherkin, Prolific Pickling.

KALE OR BORECOLE: Cottagers, Asparagus, Dwarf Green Curled, Drumhead, Improved Hearting, Sutton's Kale (variegated).

LEEKS: Ayton's Castle Giant, Lyon, Musselburgh, Broad Flag or London Flag.

LETTUCE. *Cabbage Varieties:* Marvel, Sutton's Improved Tom Thumb, Drumhead, Stanstead Park, Hammersmith. *Cos or Upright-growing Varieties:* Mammoth White, Paris White, Paris Green, Little Gem, Giant.

ONION *Spring Sowing:* Ailsa Craig, Up-to-date, Rousham Park Hero, Cranston's Excelsior, Brown Spanish, Bedfordshire Champion. *Autumn Sowing:* Giant Rocca, Lemon Rocca, Tripoli Red Italian, Tripoli White Italian. *Pickling Varieties:* Silver Skin, White Queen, Early White Gem.

PARSNIPS: Hollow Crown, Student, Guernsey or Jersey Marrow.

PEAS. *First Division* (*dwarf*): Wm. Hurst, English Wonder, Sherwood. (*Tall*): Gradus, Thos. Laxton, Bountiful. *Second Division* (*dwarf*): Stratagem, The Daisy, Sutton's Dwarf Marrow. (*Tall*): Duke of York, Duke of Albany, Sutton's Prince of Peas. *Main Crop* (*dwarf*): Sutton's Invincible Marrow, Sutton's Maincrop Marrowfat, Triumph. (*Tall*): Magnum Bonum, Dr. McLean, Fillbasket. *Late Varieties* (*dwarf*): Veitch's Perfection, Queen. (*Tall*): Ne Plus Ultra, Autocrat.

POTATOES. *First Early Varieties:* Veitch's Ashleaf, Myatt's Ashleaf, Eclipse, Sir John Llewellyn, Early Puritan. *Second Early Varieties:* Beauty of Hebron, Early Rose, British Queen, Royal Kidney, Epicure. *Main Crop or Late Varieties:* King Edward VII., Scottish Triumph, The Factor, Up-to-date, Warrior, Windsor Castle.

RADISH. *Oval or Olive-shaped Varieties:* French Breakfast, Olive White, Sutton's Gem. *Turnip-shaped Varieties:* Early Scarlet, Early White, Sutton's Earliest of All. *Long Varieties:* Long Scarlet, Wood's Frame, Long White. *Winter Varieties:* Chinese Rose-coloured, Black Spanish.

SPINACH. Long Standing Round, Sutton's Long Standing Prickly, New Zealand, Perpetual or Spinach Beet.

TOMATOES. *Red Varieties:* Sunrise, Early Ruby, Frogmore Selected, Sutton's Open-air, Laxton's Open-air, Daniel's Open-air, Sutton's Main Crop for Open air. *Yellow Varieties:* Golden Eagle, Large Yellow, Sutton's Golden Queen (all open-air varieties), and Daniel's Golden Beauty and Sutton's Golden Nugget, which are hothouse varieties.

VEGETABLE MARROW: Pen-y-Byd, Custard-shaped Marrow, Green Bush, Moore's Cream, Long White-ribbed.

RHUBARB: Champagne, Early Scarlet, Myatt's Victoria, Daw's Champion, Myatt's Linnæus.

HERBS. There is always a demand for the following herbs: Balm, Basil, Chives, Fennel, Horehound, Peppermint, Rue, Winter Savory, Summer Savory, Tarragon, Hyssop, Lavender, Mint, Marjoram, Parsley, Pennyroyal, Sage, Common Thyme, Lemon Thyme.

Theories of Dyeing. Characteristics of Textile Fibres. Mordants and Fixing Agents. Natural Dyestuffs.

TEXTILE DYEING

FORMERLY most manuals for dyers were simply recipe-books. In the days when about twenty natural dyestuffs formed his complete store-house of colour, the practical dyer recorded his results from day to day, together with patterns of the actual work. A recipe, *together with the pattern*, is still interesting and useful, but, as a rule, the dyer is now able to work without specific instructions, except as to the percentage of colour to be used. If he is given a direct cotton colour or a sulphur colour or an acid wool dyestuff, for instance, he knows that a general method is applicable in each case. Recipes without patterns are therefore of little interest to him. Where one is given in this course it is merely as an illustration, and the writer has in every case seen the pattern.

The Theory of Dyeing. Volumes have been written in the endeavour to explain how it happens that a textile fibre can be permanently dyed with a soluble colour, and no solution of the problem that will meet all cases has yet been discovered. The mechanical theory is that the dyestuff is deposited and firmly held in the pores of the fibre; the chemical theory is that there is an actual chemical reaction between the mordant or dyestuff and the fibre. In some cases one or the other theory can be satisfactorily proved; in others both theories seem to fail. Until the knowledge of the chemistry of the textile fibres, and especially of cellulose, is greatly improved, the problem will remain unsolved. We have to be satisfied with knowing that we can give yarn or cloth a more or less permanent colour without knowing why.

The Textile Fibres. From the point of view of the dyer, the practical way is to divide the textile fibres simply into animal and vegetable fibres. The types of these classes are cotton and wool, by far the most important textiles, and the differences of their behaviour towards reagents are characteristic of the animal and vegetable fibres generally, and govern their treatment in the dyehouse. Wool is destroyed by moderately concentrated alkalies, but resistant to dilute acids. Cotton is not injured by moderately concentrated alkalies, but is carbonised by mineral acids, and even rather dilute acids have an injurious effect upon it. The two fibres behave very differently to tannic acid. Cotton has a strong affinity for it, which fact is taken much advantage of in dyeing, whereas wool can be made to absorb only a trifling percentage of it, and its presence on the fibre actually prevents the wool from taking the dye. On the other hand, wool has a strong affinity for many classes of dyes; it has a powerful decomposing effect upon metallic mordants, and readily retains the oxides. Cotton is very inert, and it is comparatively recently that a class of artificial dyestuffs has been discovered which will dye it without the intervention of mordants. Wool, therefore, with certain limitations, is easier to dye than cotton. Silk, in some ways, is in a class by itself. It may be looked upon as animalised vegetable fibre, but in its general behaviour to reagents it strongly resembles wool.

Vegetable Fibres. Vegetable fibres are divided into two classes—seed hairs and bast fibres. Cotton is the only textile of importance in the first category, although many attempts have been made to utilise the fibrous growth on other seeds. Kapok, also a seed hair intended to waft the seed on the wind for the propagation of the plant, has lately come into the market. It is very light and elastic, and remarkably waterproof. Unlike cotton, it cannot be bleached with hypochlorites, but is successfully treated with peroxide and perborates, and is dyed with the same classes of dyestuff as cotton.

The bast fibres are obtained from the stem of plants, as in the case of flax and jute, or from the leaves, as in the case of ramie. In cotton, each fibre is a single cell, whereas bast is composed of bundles of cells. The differences between the vegetable fibres are mainly of structure, and concern those charged with the preparative processes rather than the dyer, who, nevertheless, is obliged to modify his treatment more or less according to the particular fibre with which he is dealing. The principal constituent of all vegetable fibre is cellulose. Cotton is almost pure cellulose, linen somewhat less pure, and all the other fibres have much more of what, from the point of view of the dyer, may be looked upon as natural impurities.

Cotton. The fibre is picked by hand and ginned by machinery. Both these operations have an effect on the subsequent dyeing operations. If the cotton is not ripe, it will dye unevenly; imperfect ginning will cause it to be full of dust, seed particles, and leaf. Leaf and seed particles are very tenacious, and may appear in the yarn or even in the cloth as black spots. In this case the oil in the seed will give trouble, and cause spotty dyeing.

Nature of Cotton. Apart from these impurities, which should not be present, cotton is composed of cellulose, water, and about 5 per cent. of constituent impurities, consisting of pectic acid, colouring matter, wax, and fatty and albuminous matters. The amount of colouring matter varies greatly; it is almost absent in Sea Island and white Egyptian, and largest in brown Egyptian. In this cotton, and in the tawny fibres of India, the fact has to be taken into account by the dyer that he is dealing with unbleached goods. The wax, together with a very delicate cuticle, which is not cellulose, serves as a sort of waterproofing to the fibre. This is the reason why the dyer, dealing with unbleached goods, is obliged to scour or wet out the cotton before entering it into the dye-bath. The fatty matter in the fibre is identical with the oil in the seed, and also requires to be removed. The influence of this wax and fat can be noted if grey cloth is steeped in cold water; it will be found that a considerable time elapses before it is wetted out. The pectic acid is an amorphous

substance resembling a gum, insoluble in cold water, but readily soluble in hot.

Bleaching, therefore, in which process alkalies are used and form soaps with the fatty matters, removes these impurities and leaves almost pure cellulose, the albuminous matter being in such small quantity as to be negligible.

This general inertness, although it is the cause of the want of affinity for colouring matter, is of valuable assistance to the dyer, inasmuch as it enables cotton to stand all the various processes through which he has to put it. Cellulose, moreover, is hygroscopic, and the moisture taken up from the air renders the fibre soft and elastic.

Mercerised Cotton. John Mercer, a Lancashire calico-printer, in 1844 discovered that cotton treated with caustic soda of a certain strength shrinks, gains strength, and acquires greater affinity for colouring matters. He took advantage of the shrinkage to produce crape effects by printing cloth in patterns of stripes with caustic soda lye, allowing it to dry, and steaming the fabric. The printed parts contract and remain smooth, dragging the unprinted parts with them, which thus become crinkled. This is one of the methods of producing the cotton crépons which are on the market.

Lustre-Mercerisation. After Mercer's time it was discovered that if a fine cotton yarn is held in tension during mercerisation, and prevented from shrinking by washing out and neutralising the lye with acid, the fine staple takes a silky gloss. The chief interest in the process today lies in this lustre-mercerisation, by which cotton is given the appearance of silk; and it is necessary for the dyer to understand the properties the cotton has acquired and the new conditions under which he must work. Generally speaking, all classes of dyestuffs ordinarily used for cotton are available, but 25 to 35 per cent. less dyestuff is required to dye to the same depth of shade, and the colour goes on much more quickly than in the case of unmercerised cotton. This tends to uneven dyeing, and the remedy is long baths—this is, with plenty of water—the employment of colours which exhaust slowly, a decreased addition to the bath of Glauber's salt, and more soda, soap, or other ingredients which retard the action of the colouring matter. In the case of dark shades, the bath, of course, must not be too long. Another point the dyer must take into consideration is that the manner of dyeing must not injure the lustre of the goods. For this reason the direct cotton dyes are largely employed on mercerised material. In union goods, when mercerised and dyed cotton is used, the dye is more liable to bleed on to the wool than ordinary cotton, and a class of dyestuffs has been introduced to remedy this.

Apart from lustring, Mercer's original idea of using caustic soda to economise dyestuff has found a limited use. It was quickly discovered that even comparatively weak lyes, not capable of contracting the cloth, would save dyestuff, and that certain wool dyes could be used on mercerised cotton. With both the natural and the artificial colours there is always an economy of dyestuff, and sometimes a simplification of the process, as in the case of several basic dyes, which may be used without a mordant. It is very necessary, therefore, that the dyer should study mercerised cotton from every point of view.

Linen. Being a bast fibre, flax is much more difficult to prepare for the spinner than cotton; and the most important operation is retting, in which process the flax is steeped in cold or hot water to remove the adhesive substances which bind the fibres to each other and to the woody portion of the stem. The method of retting is of importance to the dyer, inasmuch as it influences the colour of the product as he receives it. The fibre should then be snowy white and lustrous.

Its chemical composition is very similar to cotton, but it contains more pectic acid and other impurities, from which it is freed on bleaching, as in the case of cotton. It absorbs about the same amount of moisture, but is a better conductor of heat and is less elastic. It is more affected by caustic alkalies and bleaching agents; and although it is cellulose, and the methods employed are much the same as in cotton dyeing, it is more difficult to deal with. Even unbleached linen, however, can be readily dyed with substantive cotton colours, by boiling twice with 5 per cent. soda and rinsing well. It has some affinity for the basic dyes, as it contains a small amount of tannin. The fibre, as it comes to the dyer, contains woody and waxy impurities, varying according to the nature and thoroughness of the preparatory operations, and also cellulose converted by the pectic acid into pecto-cellulose.

The introduction of direct cotton dyestuffs, however, greatly simplified the dyeing of linen, and they are very largely employed.

Jute. The preparation of the fibre from the plant is similar to the processes used in the case of flax, but simpler, and the product is freer from woody impurities. The physical structure is the main difficulty of the dyer, and the dyed jute often shows an absolutely untouched centre if the fibre is cut across. This is of little moment, however, in the ordinary uses of jute.

It is best bleached by the successive action of permanganate of potash and sulphuric acid, but the bleach does not last. Treated as in cotton bleaching, but with weaker lyes, an imperfect but more stable bleach is obtained. The dyer has to put his best work in when the jute fibre is intended for use as a binding thread in carpet weaving, or for cheap classes of upholstery.

Hemp. A large number of bast fibres come on to the market under the name of hemp. It is fairly successfully bleached in the Dundee district by special processes, but rapidly turns brown and is tendered to some extent in the process. It is rarely dyed, but when this is required the substantive dyes are used as for cotton.

Ramie. China grass, rhea, or ramie is nearly pure cellulose, and consequently can easily be bleached. It can be dyed like cotton, but care must be taken to preserve the lustre. In light shades, obtained with the substantive colours in lukewarm baths, it has been used for curtain laces and napkins. It has also been used for upholstery.

Artificial Silk. Several varieties of this are on the market, but they are now all obtained from solutions of cellulose. They are dyed like ordinary boiled-off silk, but at lower temperatures.

The Animal Fibres. The animal fibres have nothing in common with the vegetable fibres in chemical composition, and are treated in a totally different manner in bleaching and, as a rule, in dyeing. They are nitrogenous substances, and frequently contain sulphur. The great difference between the animal and vegetable fibres is emphasised by a rough test very frequently used by dyers. Take a warp thread of a union cloth and apply a lighted match to it. It burns with a quick,

bright flame, and without smell—it is vegetable fibre. Take a weft thread and hold the light to it. It shrivels up in a brownish bead, and gives off the smell of burning horn—it is an animal fibre. The results, of course, will be reversed if the warp is wool and the weft cotton.

The chemical composition of wool fibre itself, when freed from impurities, closely resembles that of horn. It consists of carbon, hydrogen, oxygen, nitrogen, and sulphur, and the presence of this last element distinguishes it from silk.

The sulphur may cause trouble to the dyer. If the water contain lead, dull shades are produced in a neutral or alkaline bath, but this may be corrected by adding sulphuric acid, or in some cases alum. If the wool comes into contact with lead, copper, or tin, stains result, owing to the formation of the sulphides of these metals. Mordanting with a tin salt has the same result. If necessary, the sulphur may be almost removed by steeping the wool in milk of lime, washing in water, then in weak sulphuric acid, and again in water, repeating the operation several times.

Effects of Acids on Wool. Solutions of hydrochloric and sulphuric acids have little effect on the fibre except that they make it feel harsher. They are used in the dye-bath in wool dyeing, and as they are more energetic in their action on cotton they are also used to remove this fibre from rags or shoddy. One process is to steep the shoddy in dilute sulphuric acid, squeeze out, and dry in a stove at about 225° F. The cotton is carbonised and disintegrated, and can be beaten out of the goods.

Concentrated mineral acids destroy wool. Dilute boiling nitric acid is used to take out the colour from goods already dyed, as, for instance, in "stripping" garments for re-dyeing or ir. correcting dyehouse mistakes. Sulphurous acid is used as a bleaching agent, as wool would be destroyed in the process applied to cotton, and must be thoroughly removed by steeping it in very weak solutions of chloride of lime and washing well. Otherwise uneven dyeing will result, especially with light colours, which may even be destroyed by the sulphur dioxide retained in the fibre.

An excess of chlorine destroys wool, but when the fibre is submitted to the slight action of chlorine or of hypochlorite it is said to be "chlorinated," and has acquired some very valuable properties. It has a yellowish tint and a harsher feel, but it has lost most of its power of felting, and therefore the process is used to prevent the shrinking of woollen hosiery and clothing. It has also acquired a greater affinity for colouring matter. This is taken advantage of by the muslin delaine printer very extensively, and also to some extent by the wool dyer, who, for instance, can produce two-colour effects on all wool goods by chloring the warp before weaving, and leaving the weft untreated. The warp then takes up a much deeper colour in the dye-bath.

Effect of Alkalies on Wool. The action of alkalies on wool is very peculiar. While comparatively weak lye at an ordinary temperature disintegrates the fibre more or less rapidly, a short immersion in caustic soda of 82° Tw. at a low temperature, say 50° F., produces an effect analogous to mercerisation. The fibre takes a soft silk feel and scroop, and a greater affinity for colouring matters. The economy of dyestuff effected has never been sufficiently experimented upon, but two-colour effects have been produced in the piece by using "mercerised" and "unmercerised" wool after the manner of chlorinated and untreated fibres. The treated wool is also freed from sulphur to a large extent.

Wool, unlike cotton, has a positive action on metallic mordants, readily decomposing them in hot solutions and retaining their oxides in the fibre. It has also a strong direct attraction for several classes of colouring matters. Its porosity also enables it to be readily treated. This general activity makes the dyeing of wool comparatively easy, but on the other hand it has the drawback of being the frequent cause of uneven dyeing. In most cases the care of the dyer must be to moderate the action of his baths, and to regulate his work so that one portion of his goods does not absorb an unfair share of the dye.

Wool from a diseased animal dyes badly, and from the dead sheep much worse still. "Dead fibres" which have been pulled out before the sheep was sheared take the colour badly, and "kemps"—smooth, white, almost scaleless fibres, met with in coarse wools—also take less colour and may produce spotty dyeing. They are usually combed out, however, in the preparatory processes.

Silk. Raw silk consists of a double fibre cemented with a layer of silk glue. When "boiled off" the fibres are separated, and, losing the yellow of the enveloping glue, are almost white and lustrous. They differ from vegetable fibres and from wool by being devoid of cellular structure. Silk resembles wool in some respects, but it is distinguished from it chemically by the absence of sulphur. It is very hygroscopic, and will absorb 30 per cent. of moisture without feeling damp. It is very elastic and strong, and has a high lustre.

A very distinctive property is the peculiar crisp, rustling sound it emits when it is squeezed in the hand. This is known as the *scroop*, and is imitated by chemical means in mercerised cotton. What the French call the *frou-frou* is a valued property in ladies' dress material, and the retention of it has to be carefully ensured in the dyeing operations. Raw silk has no scroop, the property being imparted to it in an acid bath after boiling off. It can be imparted to it after dyeing, and this is usually done in a bath containing oil and acid. Silk is a bad conductor of electricity, and therefore becomes electrified by friction; this is overcome by keeping the air moist in rooms where it is worked.

Silk decomposes metallic mordants as readily as wool. Potassium bichromate injures the fibre, and dilute solutions of bleaching powder chlorinate it like wool, increasing its affinity for colouring, but to a less extent. It is very easily tendered, even sodium carbonate affecting it in warm solutions, and this is a point that the dyer must bear in mind. It behaves like wool to colouring matters, and can be easily dyed direct with several classes of them, and its affinity for the basic dyes is even greater than wool.

Mordants and other Chemicals. The dyer uses a large number of drugs in preparing his material for dyeing—such as mordants, as fixing agents and assistants for the mordant, as levelling agents, and as solvents for dyestuffs. The method of preparation and minute description of these substances belong to the domain of general chemistry, and very voluminous works are devoted to the subject. In this course we must consider them purely from the point of view of the dyer.

The French dyers use the term *mordant* (biting) because they thought that the mordants simply prepared the way for dyeing by biting into the fibre

and opening the pores. It has long been known that they act by forming a coloured lake, closely combined with the fibre, either by fixing the dyestuff or by actually forming an essential element in the colour. The mordant must not affect the properties of the fibre, and must penetrate it thoroughly; otherwise, if it is only superficially attached, the colour will not be fast to rubbing.

Aluminium Salts. Aluminium mordants are used on all the fibres. Alum is the double sulphate of aluminium and potassium or ammonium. Dyers prefer commercial alum to the sulphate, but they are both used as mild acids in dyeing acid colours on wool and as mordants on cotton, but not to a large extent, as very little alumina is fixed on the fibre. On wool and on silk the sulphate is the principal aluminium mordant. The other aluminium mordants are principally used in textile printing.

Iron Salts. A large number of ferrous and ferric salts are used by the dyer.

Ferrous sulphate, usually termed *copperas* or *green vitriol,* is employed in the manner described below under the head of "Natural Dyestuffs," and for darkening the colours obtained with some of the basic coal-tar colours.

Pyrolignite of iron, or *black liquor,* is ferrous acetate containing a little ferric acetate, and is used principally by the cotton printer and in black-dyeing silk. *Ferric sulphate,* very misleadingly termed *nitrate of iron,* is used very largely in black-silk dyeing and for cotton. The real *ferric nitrate* finds a limited use for buff shades on cotton.

Chromium Mordants. *Bichromate of potash* or *soda,* often simply called "bichrome," is an everyday mordant for wool. Commercial sodium bichromate is less pure than the corresponding potassium salt, but is cheaper, and is usually employed. A very small proportion of bichromate has great mordanting power—in fact, the danger lies in "over-chroming" the wool. *Chromium fluoride* is also used, generally with oxalic acid as an assistant. On silk, *basic chromium chloride* is used, fixed with silicate of soda. The cotton dyer does not use chromium mordants very largely, but uses bichrome to make certain colours faster to washing.

Khaki can be dyed on cotton with metallic oxides. The word itself means "earthy," and khaki, it is said, has been a military colour from the days of Alexander the Great. Our soldiers in India, in cases of sudden outbreak on the frontier, dyed their white cotton twills in fresh cow-dung. The Boer War brought khaki very much to the front; and a long range of drab shades produced with natural and artificial dyes are now described under the name. The military authorities are very exacting as to the properties of fastness of the dye.

Tin Mordants. The stannic salts are much used for the vegetable fibres, especially with the natural dyestuffs. The wool dyer principally uses *stannous chloride,* under the name of *tin salts* or *tin crystals. Tin spirit*—that is to say, tin dissolved in acids—is hardly used now. *Stannous nitrate* is employed in dyeing cochineal-red on wool.

Copper Mordants. The copper salts are used principally as oxidising agents, but *copper sulphate,* known as "bluestone" or "blue vitriol," is employed to some extent as a mordant in wool dyeing, and cotton dyed with some of the direct cotton colours is after-treated with copper sulphate to make the shade better able to resist washing.

Lead Mordants. *Acetate of lead,* known as "sugar of lead," and *nitrate of lead* are used by the cotton dyer in producing the once favourite colours known as "chrome orange" and "chrome yellow." The cotton is mordanted with the salt and passed through milk of lime, and then through a bath of bichromate of potash.

A large number of other metals have been used as mordants experimentally, and some of them have found a use, but principally in textile printing.

The Tannins. A large number of vegetable substances contain tannic acid, or an organic acid resembling it in chemical constitution and properties. They are capable of converting hide into leather, and their astringent properties make them useful in medicines as styptics. They are used also in the production of inks, and in the manufacture of a class of dyestuffs. Some of them, notably cutch and gambier, contain colouring matter sufficient for use as a dye, and are natural combinations of mordant and colouring matter.

The principal value of the tannins to the dyer lies in the fact that, whereas vegetable fibre has little affinity for dyestuffs, it greedily absorbs tannic acid, which is capable of forming insoluble compounds in the fibre in combination with the basic dyestuffs. In silk dyeing the tannins are principally employed as weighting material, and as both dye and weighting material for black silk. In wool dyeing they find a very limited use. The fibre has little affinity for tannin, and the small quantity that it absorbs is a resistant to some dyestuffs. Before the days of the artificial dyes, many of the tannins were used for the sake of the colouring matter they contain. Tanner's bark, gall nuts, chestnut husks, and sumach were all employed as actual dyestuffs in English dyehouses, and country people used the bark of the birch and willow and other trees. Practically, cutch and gambier are now the only tannins used as dyes; and the value of a tannin to the cotton and linen dyer largely depends upon the *absence* of colouring matter.

Tannic Acid. This is prepared for the dyer from Chinese and Japanese galls, and comes on to the market as pale yellow powder and as crystals. The commercial acid can be freed from its colouring matter by shaking it up with ether and allowing it to settle. The lower layer then is almost colourless tannic acid. It was considered necessary to use this tannin exclusively for delicate shades, but colourless extracts of sumach are now on the market, and are less expensive. Tannic acid, however, is the ordinary tannin matter in the dyehouse.

Oak galls are produced by the puncture of a female wasp, and the richest in tannic acid come from Aleppo. Chinese and Japanese galls are produced by the puncture of an insect on the trees of the *Rhus* family. These are not much used directly in dyeing, but for the production of tannic acid.

Knoppern are produced by the insect puncture of the unripe acorns of an oak grown principally in Germany and Austria. They are very rich in tannin, and the Germans use them in ink-making.

Sumach and other Tannin Sources. Sumach is the leaves of certain species of rhus which are ground up for sale. Sicilian sumach is the best, but it is very often largely adulterated, notably with the leaves of the lentisk. Sumach should contain 15 per cent. to 20 per cent. of tannin. It is a very hardy shrub, and flourishes in the South of England. As there is a market for guaranteed pure sumach, it might be profitable to grow it on waste land in England. It is very largely used in cotton dyeing, as the slight amount of red colouring matter it contains is not a disadvantage for many uses.

Myrobalans, sometimes written *myrobolams,* are the dried, plum-like fruit of several species of trees,

and are obtained chiefly from the *Terminalia* of India. The stones contain little tannin; and as they may amount to 50 per cent. of the weight of the myrobalans, this has to be taken into consideration in sampling. Myrobalans are cheaper than sumach and richer in tannin, but they contain a yellow-brown colouring matter which unfits them for light-shade dyeing. They are largely used in dyeing dark shades and black on cotton and silk.

Valonia is the acorn cap of several species of oak grown in the Levant. It contains a dirty yellow colouring matter, and is little used by the dyer, except occasionally in silk dyeing.

Trillo is a tannin consisting of the scales of the acorn caps. *Divi-divi* is the pod of a shrub grown in the West Indies. It is used in dyeing black.

Canaigre, the dried root of a specie of dock, has been suggested as a substitute for sumach. It is very rich in tannin. The English dock was experimented upon, but the attempt to cultivate it as a tannin does not seem to have been successful. A large number of other tannins, such as quebracho and algarobilla, are used by the leather tanner.

Oils. Olive and castor oil are converted into "Turkey-red oil," or sulphated oil, by treatment with sulphuric acid. Castor oil is principally used in England. It is decomposed with concentrated sulphuric acid, and the mixture of fatty acids resulting is washed with common salt, and neutralised with caustic soda. It must be perfectly neutralised or slightly alkaline, and is then soluble in distilled water to a clear solution. It is used as a mordant for basic colours in some cases, but the shades it gives, although brighter, are not so fast to washing as those got on a tannin mordant. It is indispensable in fixing mordants for alizarine dyeing. In the old process of Turkey-red dyeing with madder, rancid olive oil was used. Lately Turkey-red oil preparations in the convenient form of soaps have come into use, *Monopol soap*, *Tetrapol*, and the *Polysulfol oils and soap* among others, and find many uses in dyeing.

Fixing Agents and Assistants for Mordants. The mordants require to be decomposed, and the oxide, which is the actual mordanting agent, must be firmly fixed on the fibre. Wool is capable of decomposing mordants unaided, but, as in chrome mordanting, not without some injury to the fibre. Fixing agents, or assistants, are therefore added to the bath.

Caustic Soda. This is used sometimes as a solvent for alumina and stannic oxide. It is used in the production of *manganese brown*, also called *manganese bronze or bistre*, formed by fixing manganic oxide upon cotton. This colour is very fast to light and washing, and is now also obtained by steeping the cotton in a solution of manganous chloride, drying in the hot flue, and passing through a warm solution of potassium permanganate. Caustic soda also fixes ferrous or ferric oxide on the fibre, producing in this way two other mineral colours, known as *iron-buff* and *nankin-yellow*. It is very largely used in mercerisation, and at a certain degree of concentration has the effect of increasing the affinity of the cotton fibre for dyes.

Sodium Phosphate. This is a useful assistant with aluminium mordants.

Sodium carbonate finds many uses in dyeing. The *soda crystals* are the familiar "washing soda" of the household. In a crude, calcined form, the carbonate is called *soda ash*. It is largely used for softening water, for neutralising acids, and for fixing ferric and chromic oxides on cotton.

Sodium sulphate or *Glauber's salts*, and *sodium chloride* or *common salt*, may be considered together, as the dyer uses them for the same purpose. Neutral Glauber's salts should be in clear, transparent crystals, containing no iron. Calcined Glauber's salt is made by driving off the water of crystallisation, and very much less of this is needed in the dye-bath. Common salt and Glauber's salt are used in the dye-bath to aid the colour to go on the fibre.

They are often used in large quantities, and raise very considerably the boiling-point of the liquor, which has a beneficent action in some cases. In woollen dyeing they render the colour less soluble, so that it is dissolved more gradually, and goes on the wool more evenly. Glauber's salt or common salt is very frequently the only addition to the dye-stuff in dyeing with the direct cotton colours, especially in dyeing mixtures of wool and cotton, in which case the bath must be neutral.

Sodium bisulphate, or acid sodium sulphate, is used as a milder substitute for a mixture of Glauber's salt, and sulphuric acid. It is sometimes called *tartar substitute*.

Sodium sulphide is used as a solvent, or, rather, reducing agent, for the sulphur colours which are insoluble in water alone.

Sodium phosphate is sometimes used in Turkey-red dyeing as an assistant for aluminium mordants.

Ammonia is used for neutralising acids, and in all cases where the wool dyer needs a weak alkali. It is used for neutralising Turkey-red oil, as its volatility allows it to be readily driven off.

Lant—that is, stale urine—is the mildest form of ammonia.

Ammonium carbonate is used for scouring wool, and is one of the best agents for fixing alumina on cotton.

Tartar emetic is largely used for fixing tannic acid in dyeing cotton with basics. It is *antimony potassium tartrate*, but is invariably called tartar emetic in the dyehouse. Its expense has caused many substitutes to be offered. *Antimony potassium oxalate*, known as *binoxalate of potash*, which is cheaper, may be used in some cases. A double salt—*antimony fluoride and sulphate*—has been sold for the purpose, and there are various patented preparations on the market.

Potassium ferrocyanide, known as *yellow prussiate of potash*, and *potassium ferricyanide* (*red prussiate of potash*) have been used as mordants instead of tannic acid. The yellow prussiate is used in dyeing aniline black. *Prussian blue* is perhaps the most important of the mineral colours. It is produced on cotton or silk by dyeing the material iron-buff [see Caustic Soda above], and passing it through a weakly acid bath of yellow prussiate, and on wool by dyeing with yellow prussiate in a strongly acid bath at the boiling-point.

Argol, or *argols*, is the crude cream of tartar in the lees of the wine vat, and is red or white according to the colour of the grape. It is added to mordants, especially to alum, the resulting double salt giving up more alumina to the fibre. The decomposition of the mordant with argol produces tartaric acid, which does not affect the dye-bath, whereas if sulphuric acid were used to decompose the mordant, and remained in the fibre in the dye-bath, it might injure both the colour and the material.

Calcium Salts. When *quicklime* is slaked, *calcium hydrate* is produced. Water dissolves very little of this, and the *lime-water* holds particles in suspension. This is known as *milk of lime*. It is largely used in fixing iron mordants and in bleaching. *Carbonate of lime*, or *chalk*, is used in fixing alumina

in alizarine dyeing, as lime in some form or other must be in the dye-bath. *Acetate of lime* is very frequently employed for this purpose, and also in dyeing with several of the natural dyestuffs. *Chloride of lime* (bleaching powder) is a misnomer. It is really a hypochlorite.

Acids. The mineral and organic acids are extensively used as solvents, neutralising agents, reducing agents for mordants, and for many other purposes.

Soap is very largely used by the dyer. It is a necessary assistant in many dye-baths, and the ordinary way of dyeing silk is to use a soap-bath plain, or "broken" with acid. It is a very useful plan to "soap" dyed goods in order to brighten the colours. The dyer needs soap of a good quality, and, as a rule, neutral.

Quillaia, variously known as quillaia bark, Panama bark or wood, and soap bark, is the bark of several species of Rosaceæ, growing in Chile, Peru, and Brazil. It contains saponine, which has great lathering and cleansing power. The wool dyer uses it where soap would be inadmissible, and it has no harmful effect on the most delicate dyes.

Natural Dyestuffs. Local uses are made of a large number of natural dyestuffs even in the British Isles, but it is not practicable to consider any colouring matters of this class that are not ordinary articles of commerce. The natural dyestuffs are drawn mainly from the vegetable kingdom; a very small group are of animal origin. The coloured oxides of many metals can be fixed on the fibre, but these are used as mordants, and the few mineral colours are of little importance in dyeing, and have been mentioned in describing the salts which produce them. Bancroft, whose "Philosophy of the Permanent Colours" was published in 1794, divided the natural dyestuffs into two groups—"substantive," those with which no mordant is necessary; and "adjective," those that could not be fixed on the fibre without a mordant. These terms are now used in connection with the artificial colours. Even before the days of synthetic colours the number of natural dyes in general use was very limited. Apart from the mineral colours, logwood, madder, peachwood, camwood, barwood, sanderswood, cochineal, indigo, old fustic, weld, quercitron bark, cutch and gambier, turmeric, sumach, and gall nuts almost exhaust the list. They were generally used in combination, and thus a large range of tint was obtainable.

Indigo. Indigo, unfortunately, is decreasing in importance year by year. It was long looked upon as the queen of dyestuffs. Indigotin is the blue-colouring principle in indigo, and artificial indigotin has put the natural dyestuff more and more in the background. It is probable, nevertheless, that indigo will always find limited uses. The indigofera are very numerous, but the plants cultivated principally are I. anil (whence the word "aniline"), I. argentea, I. disperma, and I. tinctoria. The last of these is most extensively cultivated. The colouring matter of the woad plant, *Isatis tinctoria*, is identical with indigo, but the dyer used woad only as a ferment in the indigo vat.

Indigo is absolutely insoluble in water, but on treatment with an alkali and a reducing agent it is converted into indigo-white, which dissolves in the lye. When cloth is steeped in the vat thus made, and exposed to the air or passed through an oxidising agent, the indigo-blue forms on the fibre. In the woad vat the indigo is reduced by taking up the hydrogen produced by fermentation, and indigo-white thus obtained is dissolved by slaked lime. Madder is used in this vat, which is employed principally for heavy woollens, and requires skill and experience. The zinc vat is largely used in England for cotton, and is perhaps the simplest of the indigo vats. Indigo, zinc, lime, and sometimes iron filings are added to the water, which is kept stirred for eighteen hours, and then left to settle. The zinc decomposes the water, and the hydrogen reduces the indigo as in the case of the fermentation vat. The iron filings form a rough surface, aiding the evolution of the hydrogen, and form a galvanic couple with the zinc. A large number of vats are in use, each having advantages for a particular purpose. They all depend on the same principle of the reduction (or hydrogenation) of the insoluble indigo-blue to the soluble indigo-white:

$$\underset{\text{Indigotin}}{C_{16}H_{10}N_2O_2} + \underset{\text{Hydrogen}}{2H} = \underset{\text{Indigo-white}}{C_{16}H_{12}N_2O_2}$$

The indigo-white is fixed on the fibre, and on reoxidation is reconverted into the insoluble blue:

$$\underset{\text{Indigo-white}}{C_{16}H_{12}N_2O_2} + \underset{\text{Oxygen}}{O} = \underset{\text{Indigo-blue}}{C_{16}H_{10}N_2O_2} + \underset{\text{Water}}{H_2O}$$

The blue fixed on the fibre cannot be washed off again, and it is easy to see from this the great advantages and the one fault of indigo. It is very fast to light and washing, but the outer part of a fabric will lose some of its colour by rubbing. Indigo contains red, and generally some brown and yellow colouring matters in addition to the blue; also a body which becomes a sugary substance like gluten. These play a part in dyeing, but their exact nature is not known. They give indigo, however, properties that are absent in indigotin or artificial indigo.

Principal Indigo Vats. Some of the principal vats are as follows:

The *copperas vat* is not so simple as the zinc vat, but it is cheaper, and English dyers have used it for cotton since the time of Elizabeth. The vat is "set" with indigo, copperas (ferrous sulphate), fresh slaked lime, and water. In this vat the lime is an active reagent, as well as a solvent for the indigo-white. It combines with the copperas to form ferrous hydroxide, which reduces the indigo. The lime must be in excess to provide for its use as a solvent. This vat requires experience, and it is left to the experts who know how to humour it.

The *hyposulphite or hydrosulphite vat* is a modern vat very much in favour, as it can be used for both wool and cotton. Acid hyposulphite of soda is the reducing agent, and the dyer prepares this by the action of zinc on sodium bisulphite. The hyposulphite is prepared immediately before use, and added to indigo, ground into fine powder, and slaked lime. The vat is used cold for cotton and lukewarm for wool.

In *fermentation vats* any substances such as bran, starch, or glucose which will ferment may be used, as has already been explained in the case of woad. Benoist and Collins actually made a culture of the ferment that produces hydrogen—*Desmobacterium hydrogeniferum*—and added a trifling proportion of it to a vat prepared with food for it. The advantage of it is that this can be worked at a higher temperature than other fermentation vats; therefore it is more rapid in its dyeing action and more easily worked.

In the *stannous hydrate vat*, stannous chloride with caustic soda is the reducing agent. It is said

to be simpler than the copperas vat, but is little used in England.

The different vats have an influence on the shade. The woad gives the brightest shades, and the alkaline vats are best for the dark shades required for uniforms.

It has always been necessary, in view of the high price of indigo, to recover the unspent dye from the "bottoms." The copperas vat, in particular, is not exhausted. Many devices have also been used to combine indigo with other dyes, to obtain its peculiar bloom and excellent qualities with less expense. A very usual plan is to "bottom" the goods with camwood or barwood first, and afterwards with indigo, or the indigo is "topped" with suitable artificial dyes after a light shade of indigo has been obtained in the vat. These shades are termed "woaded" colours.

Natural indigo is holding its own best in woollen dyeing in the fermentation vats. Natural indigo is more suitable than artificial indigotin for use in these vats, which leave the wool with a softer feel than the chemical vats.

The hydrosulphite vat, however, is much the simplest, and is the one ordinarily used for artificial indigo and for other highly important vat-dyes to be described later in this course.

Natural Dyestuffs. *Logwood.* This dyewood has withstood the attack of the artificial dyestuffs better than any of the natural dyes, on account of its cheapness, comparative ease of application, the beauty of its shades, and its excellent qualities of fastness to light, washing, and acids. The best quality was formerly grown in the Bay of Campeachy, and the French still call it Campeachy wood, but Jamaica logwood is now considered the best. Logwood contains a yellowish-white crystalline body known as *Hæmatoxylin*, which oxidises in the air and takes a high colour. It is then known as *hæmatin*, the actual colouring principle of the wood.

Logwood reaches England in large logs, and these are converted into chips, plentifully sprinkled with water, and exposed to the air. The temperature and state of the weather has a great influence on the wood during this process of "ageing," and it requires experience. In unskilled hands the wood may be over-oxidised and the colour lost. This has brought logwood extracts into favour, and in particular hæmatin, procurable in liquid, powder, or crystals. These are dearer, however, than the wood, which must still be used for many purposes.

Logwood is dyed in the usual manner employed for mordant colours. The material may be dyed first, and then mordanted, a method sometimes preferred by the wool dyer, but it is usually mordanted and then dyed. The one-bath method, using dye and mordant together, is sometimes used, but causes a waste of dye, and for the same reason —that is, the precipitation of the dye in the bath —the colour is liable to rub off the goods. Even when cotton or wool is first mordanted and then dyed, there is still loose colour on the fibre, and to fix this the goods are mordanted again after dyeing —a process which is called *saddening.*

Dyeing Cotton with Logwood. Logwood is used exclusively for full, bloomy blacks on cotton, rarely for greys. An iron mordant is used, fixed with tannin. The modern practice hardly differs from that followed in the days before the aniline dyes, and the following old and approved recipe is little varied from :

Full Black on 20 lb. Cotton. To a vat of cold water add 5 lb. of sumach. Enter the goods, give a few turns, and leave all night. Then pass through lime-water ; add to this 2 lb. of copperas solution and a pailful of the old sumach liquor. Enter and give six turns, wring out ; enter the lime vat again, and give two pails more lime liquor. Then scald 6 lb. of logwood and 1 lb. of fustic; add this to another vat of water, enter, and give ten turns ; lift, and sadden with a little copperas—in the same liquor—and soap.

Sumach is now used in a hot solution, and a proportionate amount of logwood and fustic extracts are employed. For the best class of goods "nitrate of iron" (ferric sulphate) or acetate of iron is used instead of the copperas. A very ordinary method with cotton cloth is to pad the goods in acetate of iron, dry, pass through lime-water, and dye in logwood extract. Another largely used process is to used sulphate of copper as the mordant. Formerly, the best purple that could be dyed was got with logwood, and this is still used occasionally.

Fast Purple on 20 lb. Cotton. Give a blue bottom in the copperas vat, then a few turns in cold water, with a little stannous chloride at 2° Tw. In another vat add 4 lb. or 5 lb. of logwood previously spent, and give eight turns.

Lavender shades are dyed in the same way, with less logwood, and light blues are dyed in the copperas vat. Chrome may be used as the mordant in black dyeing, but the result is not so good as with iron.

Dyeing Wool. As lately as 1890, Hummel asserted that "logwood is the essential basis of all good blacks on wool." The mordants are generally either copperas or chrome. The latter is now the favourite, but it makes the wool harsher than copperas, and liable to take a greenish cast if the chroming is not uniformly done.

Black. The wool is mordanted as usual with chrome—that is to say, with 3 lb. bichromate of soda and 1 lb. of sulphuric acid to 100 lb. of goods. The dyeing is done at the boil, with 50 lb. of logwood, the shade being toned as before with fustic. Where yarn has to stand milling with white yarn it is saddened as already noted. A direct black may be made by precipitating the logwood with the chrome, the lake thus obtained being dissolved with oxalic acid for use.

Wool is frequently given a light bottom in the indigo vat, and dyed either a copperas or a chrome black. These are called *woaded black.*

Blue. For 100 lb. of goods prepare a bath with 10 lb. alum, 6 lb. argol, $1\frac{1}{4}$ lb. tin crystals, $\frac{1}{4}$ lb. sulphuric acid (D.O.V.). Boil in this for two hours, then dye in a bath containing from 10 to 15 lb. logwood extract and 1 lb. soda.

A light blue is dyed by mordanting with $\frac{3}{4}$ lb. of alum and $\frac{3}{4}$ lb. of chrome per 100 lb. of goods, and dyeing with about 100 lb. of logwood raspings, boiled up in bags. A recipe for a logwood blue, resembling indigo, on 100 lb. of wool was to mordant for one hour with $\frac{1}{2}$ lb. of bichrome, 2 lb. of alum, and $\frac{1}{2}$ lb. of red argol, then dyeing with 20 lb. of logwood.

Other Colours. Logwood greens would probably not be considered satisfactory nowadays. They were dyed on a chrome and alum mordant with fustic and logwood. About three times as much fustic as logwood gave a light green, and by adding a larger proportion of logwood any shade of dark green could be obtained. Drabs were obtained by mixtures of logwood, barwood, and fustic, after-treated with copperas. By various proportions of these dyestuffs a large variety of shades were produced on a chrome mordant, light drabs to a dark brown, and greens, purples, clarets, and olives.

Dyeing Silk. Logwood is largely used for silk; exclusively for black. The silk dyer weights the silk in the operation, and as the process is long and intricate, and varies with each description of silk, it is beyond the scope of this chapter.

Cutch and Gambier. These closely allied dyestuffs are still largely used by the dyer, and will probably be able to compete with the artificial dyestuffs for many years to come. Bombay cutch, or catechu, is considered the best quality, and is obtained from the species of *Areca*. Bengal cutch, containing more tannin but less colouring matter, is obtained from species of *Acacia* and *Mimosa*. Gambier, somtimes called cube or yellow cutch, is obtained from a Batavian shrub, *Uncaria catechu*. Formerly it was thought that these dyestuffs were earthy matter, and they were called *terra Japonica*, or Japanese earth. Gambier was looked upon as merely an inferior quality of cutch, but the main differences seems to be that it is less oxidisable; and an article on the market, known as *patent cutch*, is prepared from gambier by adding oxidising agents.

Cutch and gambier have been classed as tannins, and, as a matter of fact, they contain about 60 per cent. of tannin to 8 per cent. of colouring matter. This colour puts cutch and gambier out of the question for mordanting cotton, but gambier in particular is largely used in tanning. The reactions of cutch with the various mordants is very varied, and it is used for a variety of compound shades, especially browns, drabs, and fawns, which are very permanent. The quality of the dyestuff is usually gauged by the extent of its solubility in cold water. Gambier is almost insoluble, but dissolves readily in hot water.

Dyeing Cotton with Cutch. An old recipe says: *Brown on* 20 *lb. Cotton.* Spend 6 lb. of cutch with 6 oz. of sulphate of copper in boiling water. Turn the cotton over in this bath for about fifteen minutes; enter another bath made up with bichromate of potash at the boil. Repeat the baths until the cotton is dark enough. This is nearly the modern practice, except that the cotton is allowed to lie some hours before entering into the bichrome bath. Cutch and gambier are largely used, together with other natural colouring matters and with artificial dyes, to produce compound shades.

Dyeing Wool. Wool is dyed like cotton, but cutch is not a favourite with the wool dyer, as it gives the material a harsh handle. Used, however, for light browns, there is nothing to object to in a cutch-dyed woollen or worsted. Wool is dyed much in the same way as cotton. It is worked for an hour at the boil in the cutch bath without addition, and then chromed in a fresh bath.

Even for full shades the harshness of handle can be avoided. The cutch is ground up thoroughly in cold water, and allowed to stand and settle for some time. The water is then decanted off, and the residue, which is mostly the essential colouring principle of the dyestuff—that is, catechin—dissolves in the boiling bath, and is used for wool dyeing, with an after-treatment with bichrome or sulphate of copper.

Cutch has long been used as a constituent in khaki dyeing. One fairly old method was to mordant with myrobalans and sulphate of copper, and then dye with cutch and a redwood with a little sulphate of iron, finally chroming. The shade could be varied by altering the proportion of the iron and copper salts.

Dyeing Silk. Gambier is largely used in silk dyeing, as it acts as a weighting material as well as a dye, and resists the soap-baths, which cutch does not. As long as weighted silks can find a market, gambier will be a most important weighting material to the silk dyer, as he can use as much as 200 per cent. in the bath.

Madder. Madder is the root of the *Rubia tinctorum*, a plant indigenous in Asia, but long cultivated in Europe. Formerly it was looked upon as the most important colouring matter for the calico printer. In dyeing, it was used to produce the brilliant Turkey-red on cotton, by a long, difficult, and even dangerous process. In this use it is now supplanted by artificial alizarine.

Madder still finds a limited use in wool dyeing, generally together with other natural colouring matters to produce very fast drabs, especially on thick felted material such as hat bodies, on account of its penetrative power, which is not possessed by its substitutes. Madder gives a wide range of shades with the various metallic mordants.

Both the colouring principles of madder, alizarin and purpurin, are produced synthetically at a much lower cost than an equivalent quantity of natural madder, and the ease of application is altogether in their favour. Madder, however, contains also a brown colouring matter that is absorbed by wool.

Its great penetration makes it serviceable for dyeing thick felts—hat bodies, for instance. Even for this limited use, madder is less and less employed, as certain artificial colours have been invented which give perfectly satisfactory results. These, moreover, can be combined with fustic or logwood in a similar manner to madder.

The Redwoods. These are divided into two categories—the *close* or *hard* woods, such as camwood, barwood, and sandal, also called sanders or saunders wood, and the woods in which the colour is much more soluble, obtained from several species of *Cæsalpinia*. These have a strong family likeness, and are termed indiscriminately Brazil wood or peachwood in the dyehouse. Peachwood has nothing to do with the peach-tree; it is so called because it was imported from Campeachy.

Insoluble Redwoods. The two categories are known as insoluble and soluble redwoods, although the first term is not correct; the hard woods are soluble slowly, and with difficulty.

Mahogany is closely allied to these woods, and used to be employed for very fast drabs on cotton, especially in places where mahogany sawdust could be procured cheaply. The writer has seen a pattern prepared for the instruction of students, but the colouring matter is too weak for practical use.

Camwood is the strongest and most serviceable, and the shades it gives are very permanent.

Barwood resembles camwood, but it is practically insoluble in cold water, and boiling water parts with much of the colour it takes up when allowed to cool. The method of dyeing on wool is to *stuff*—that is, to boil in contact with the wood in a state of sawdust; the particles of wood must mix with the fibre—and to after-treat or *sadden* with the mordant. This is the usual process with the other insoluble redwoods.

Sandalwood is very similar to barwood in its properties, but the solution smells like orris, whereas the barwood concoction is odourless. These woods cannot be used on silk, the method of dyeing proscribing it. Barwood red on cotton was known as *mock Turkey-red*, but the alizarines have driven this out of the field. These woods are chiefly used now for compound shades on wool obtained by using them with logwood and fustic.

The Soluble Redwoods. Brazil is said to have obtained its name from its flame-coloured

forests (*brassas*, a glowing fire), but the "Brazil woods" now come from many parts of the world.

Brazil wood was a Government monopoly at one time, and was hence called by the Portuguese *queen wood*. The Brazilian supply near the coast was used up, and although it was grown in abundance in the West Indies the demand for it was so great that the supply was quickly and extravagantly exhausted. There is probably very little Brazil wood properly so-called on the market.

Pernambuco, Lima wood, Sapan wood, Peach wood, which is also called *Nicaragua wood*, or *Santa Martha wood*, and *Jamaica wood*, all contain the same colouring matter, *brazalin*, in varying qualities. They are used to some extent in silk dyeing, giving shades, however, inferior to those obtained from cochineal. They are principally used on alum-mordanted wool to get bright crimsons, and to dye purples on a chrome mordant.

Fustic. This is the wood of the *Morus tinctoria*, grown principally in Brazil and the West Indies. It is known also as old fustic, Cuba wood, and yellow Brazil wood. Fustic is not used in cotton dyeing, and only on silk for compound shades with other dyestuffs. It is principally used as an extract procurable in red or yellow shades, and for heavy woollens. It is the most important of the natural yellow dyes, and has been greatly in request lately as the constituent for khaki. On a chrome mordant it gives the pretty shade known as *old gold*. The brightest and fastest yellows are got with stannous chloride as a mordant. It is used principally, however, for compound shades, as the yellows are not very permanent. With copper sulphate it gives olive shades, and the dyeing can be done in a single bath. Dark olives are got with ferrous sulphate as a mordant, and the single-bath method gives good results.

Fustet or *Young Fustic.* This is the wood of a species of sumach, *Rhus cotinus*, and was formerly called *Venetian sumach* by English dyers. The French dyers first called it *fustet* or *fustoc* and as the names *fustet* and *fustic* were easily confounded, "young" was added as a qualification, although fustet has no relation to old fustic. It was never, we believe, used for cotton, and the yellows and oranges it gives on wool are very fugitive. Hummel, in 1885, said that "it would be no great loss if it disappeared from the market altogether," and it is now almost obsolete.

Bark or *Quercitron.* This is the inner bark of an oak, *Quercus nigra*, indigenous in North America. The decoction has a yellow-orange colour, and much is used fresh. It is sold also in the form of an extract. It contains a large percentage of tannin, and was formerly used for dyeing cotton yellow. It is now principally used in calico printing.

Flavine. This is a preparation of quercitron bark imported from America as a fine, light dun-coloured powder. It is stronger and gives brighter shades than bark, and has almost superseded quercitron in the dyehouse. Its principal use is on wool, to give bright orange shades on a tin mordant.

Annatto. This dyestuff, sometimes written *annotta* or *arnotto*, is obtained from the pulp enclosing the seeds of the *Bixa orellana*. Its importance in England largely depends upon the necessity of imparting to butter the "natural" colour which the British public expect to find. It is still used in silk dyeing, however, for orange shades in a soap-bath, no mordant being required, and for the compound shades with indigo, logwood, and other natural dyestuffs.

Weld or Wold. This plant, *Reseda luteola*, a species of mignonette, is extensively grown in France, and comes on the market as a dyestuff in small, dried bundles of stems. The more slender these are the better the quality. With alum it gives the fastest and purest yellow shades on wool procurable with a natural dyestuff, but it is weak in colouring power, and this greatly limits its use. The green known as "carriage-green" used to be produced by topping indigo-dyed cloth with weld. Weld is the most important natural yellow for silk, as the colours are fairly fast to light and soaping.

Safflower. This is the dyed florets of a species of *Carthamus*. It contains a red dye, and a worthless yellow colouring matter. According to Charles O'Neill, "it yields the most delicate shades that the art of the dyer can produce." It has also the distinction of being the only dye formerly used for legal "red tape." It yields very fugitive shades, however, and is now hardly ever employed. In both silk and cotton dyeing it is almost superseded by safranine, an artificial dyestuff.

Turmeric. This is the rhizomes of various species of *Curcuma*. They resemble ginger, and are put on the market in the state of powder. It is a substantive colour, going on to all fibres direct; in fact, no mordant has been found for it, and it produces very fugitive shades. It finds a limited use, however, in mixture with some of the natural dyestuffs, and with the acid colours on wool. It is occasionally used for oranges and yellows on silk.

Orchil and *Cudbear.* A species of lichen known as *Rocella*, found in great abundance in the Canaries and the Cape de Verde Islands, gives a colouring matter sold as paste under the name of orchil, or archil, or as a red powder called cudbear. A dry paste used to be prepared and sold as *persis*. Several preparations known as *orchil carmine*, *fast orchil*, and *French purple* are made, but are almost obsolete. Cudbear gives a bright bluish-red on silk, and is still used. On wool it is simply applied without mordant in a slightly acid bath, and gives depth and richer tint to reds dyed with safflower and cochineal. The shades are not very permanent, and these lichen colouring matters are largely superseded.

Cochineal. Cochineal is a small female insect, the *coccus cacti*. It was thought to be the grain or berry of a plant, and the tints produced with it are still sometimes called "grain colours." It gives the finest procurable shades of crimson, red, purple, and scarlet on wool and silk, but it has been largely superseded by the azo dyes, and by far the greater portion of cochineal imported into England goes to the confectioner. The colouring matter, carmine or carminic acid, is extracted from it on a large scale in France, and is used for colouring artificial flowers. Its principal use in England was for army cloths. With a mordant of tin salts it gives a scarlet, and with alum a crimson on wool, and these are practically the only uses to which it is now put. The scarlet is toned by the addition of a little yellow dye, usually flavine or fustic. Crimsons and scarlets were formerly dyed on the same mordants on silk, but the shades are not very fast to light, and the azo dyes are almost exclusively used.

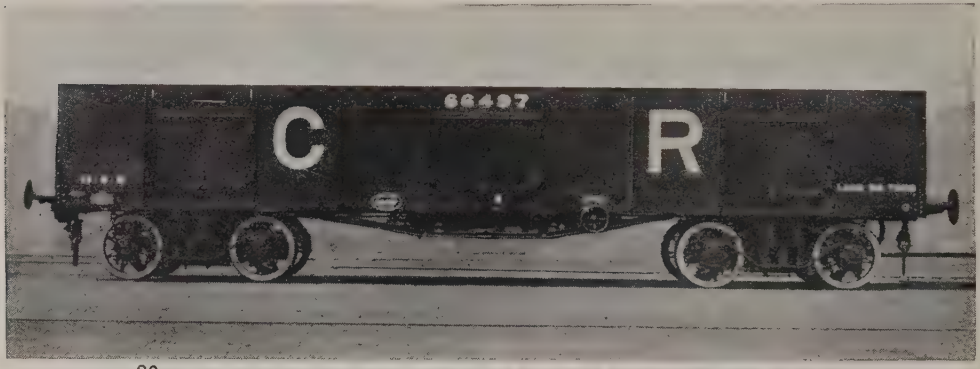
Kermes. This is the dried bodies of another species of the coccus insect, and the colouring matter is identical with that of cochineal. It is very much weaker in colouring power, and even before the days of the artificial dyes it was little used in England.

ARTHUR MORRIS

SOME TYPES OF RAILWAY VANS & TRUCKS

78. TWENTY-TON MINERAL WAGGON WITH SIDE-LEVER BRAKE AND EIGHT BOTTOM DOORS

79. BALLAST BRAKE-VAN, WITH PLOUGH FOR STONE BALLAST



80. A THIRTY-TON MINERAL WAGGON ON THE CALEDONIAN RAILWAY

81. LOW-BEDDED TRUCK CONVEYING A LARGE TANK

82. STEAM-HEATED FRUIT-VAN, WITH VENTILATORS OPEN

83. UNBRAKING A WAGGON

84. WAGGON FOR STRAW HATS AND FEATHERS

Railway Waggons. The Carriage of Goods. Consignment Notes. The Delivery of Goods. Rates. New Systems of Main Control. Flat, Gravitation, and "Hump" Shunting.

MERCHANDISE TRAFFIC

WHEN the man in the street speaks of a goods train he has in his mind a train conveying either merchandise or minerals, and does not pause to differentiate between what really form two distinct classes of traffic. To a certain extent he is warranted in confusing the two. For the purpose of classification, *goods* are defined as anything entering the Railway Clearing House Classification Schedules A, B, C, and Numbers 1, 2, 3, 4, 5, the basis of which classification is their value or the cheapness with which the articles can be conveyed, while other factors that are taken into consideration may be summed up as weight and bulk, method of packing, and liability to damage. Further, the Clearing House "Rules and Regulations" only speak of a *goods train*, which "is understood to include all trains except those composed of coaching stock." However, in practice, the mineral traffic is a thing apart, and it may be defined as covering the transport of coal, coke, iron ore, and patent fuel, while some companies include in it granite, slag, and limestone—in short, the heavier and cheaper articles. The mineral traffic conveyed annually by the railways of the United Kingdom now amounts to 350,000,000 tons, and this traffic consists largely of coal.

Private Ownership of Waggons. The first railways were constructed, like the canals, with the idea of the motive power and the moving or rolling stock being supplied by the public. The railways were to be improved roads, for the use of which customers—that is, the old-established firms of carriers—were to pay tolls, while either renting or providing their own terminal conveniences.

Presently complaints became general that the carriers stood between the public and the companies, so in 1847 the London and North-Western Railway entered into a new arrangement, by appointing the carriers merely cartage agents for the collection and delivery of goods, and by taking over the sheds and warehouses which the latter had provided. This system became common to railway companies, and endured for a considerable period, although it proved the source of constant disputes, difficulties, and additional expense. The public requires the movement of its merchandise to be one transaction, from the door at which it goes to its destination. It does not want a middleman in the shape of a cartage contractor. Cartage at a cost price leaves the railway rate to be discussed on its merit; whereas cartage by a contractor, who requires a good profit, exhausts the elasticity of the railway rate.

The modern system of the railway companies undertaking cartage and delivery was gradually evolved as lines extending into districts where no large carriers existed, and, again, as competitive lines sprang up, and the last-comer found that its rivals had already appropriated the existing cartage connections. In these circumstances the railways had to organise their own equipment for collection and delivery. Having once established cartage machinery, the feasibility of getting rid of the carrier-middlemen presented itself to the companies. It was some years before the London railways carried any goods other than merchandise and live-stock. When railways generally first accepted the carriage of coal, coke, lime, salt, and so on, they decided not to let out their waggons for these classes, which are largely dealt with in private sidings, but to convey them in "private owners' waggons" at a reduced rate. The North-Eastern Railway, however, was bound by statute to provide trucks for mineral traffic, and permitted to make a fair charge for their use. Recent legislation has recognised the general practice of the companies not to supply waggons for mineral traffic, and has expressly enacted that they shall not be required to provide waggons for this traffic.

Spiller's Case. An important case touching the right of traders to run their own waggons over a railway, and to receive a rebate from the railway rates for their use, was decided by the Court of Appeal in 1910. A firm of Cardiff millers (Messrs. Spiller) expressed a strong desire that their traffic should be carried in covered vans; and because the Great Western Company could not guarantee this, the firm built a supply of 300 covered vans for themselves, contending that sheeted trucks were not suitable for the purpose. The firm also claimed that when they found the waggon they were entitled to a rebate from the actual rate charged, equal to the maximum charge for waggon hire. The company contested this view, on the ground that it was onerous for the traffic to be sent in the firm's waggons, as it necessitated the vehicle being brought back to Cardiff without charge, whereas when the railway company's truck was used the truck was frequently, after being unloaded, reloaded at the station of destination to some other point. The railway company, therefore, would have been doubly affected by the claim—first, by the rebate allowance claimed in respect of the firm's waggons, and, secondly, by the expense of bringing back the empty waggons, and holding them at the disposal of the firm, which did not possess a single yard of sidings. The Master of the Rolls decided in favour of the Great Western Railway, and five other Lords Justices delivered concurrent judgments. So now we know that no obligation rests upon a company to convey merchandise otherwise than Clause A; that is, minerals, and certain other traffic specially mentioned in the Provisional Order, in "private owners' waggons," and that for such traffic as grain and flour a sheeted truck is a "suitable vehicle," and therefore its provision is a "reasonable facility."

There are now about 650,000 private owners' waggons and 750,000 company-owned waggons on British railways. Formerly private owners' waggons were a source of constant trouble and anxiety, as they were run up as cheap as possible, and allowed to lapse into a ramshackle condition. The Midland Railway obtained Parliamentary powers in 1881 to borrow a million sterling for the purpose of buying up from some 300 different owners the 40,000 mineral trucks which were running on its system, and building others for the conveyance of coal and other traffic. Having done this, however, it did

not sufficiently reduce its charges for waggon hire to induce traders to use the railway vehicles, and the consequence is that almost as many private owners' trucks are now to be found on the Midland system as on any other. At last, the insecurity engendered by the bad condition of privately owned waggons caused the Board of Trade to intervene.

The Board issues from time to time a "standard specification," accompanied by drawings and dimensions, to which private owners must build. It also provides that when the waggons are complete, and before they are permitted to run upon the railway, they must be examined by the company's waggon superintendent; and if he is satisfied that all the requirements of the specification have been duly complied with, he affixes to both sides of each waggon a register plate. The waggon is then free to work over that company's or any other line of railway, the arrangement being a mutual one between all the railway companies in the country. The latest regulations for private owners' waggons bear date April, 1903. They enjoin the abolition of dumb buffers as from 1910, but an addendum provides that on and after January 1st, 1914, no waggons will be allowed which are not fitted with spring buffers of approved type. They impose limitations on the tare, with the object of restricting the dead weight to be hauled; all ironwork and springs must undergo specified, rigorous tests; the use of oil in lieu of grease axle-boxes is obligatory, and the pressure at which wheels must be fixed to the axles is fifty tons per square inch, instead of thirty tons as formerly.

Varieties of Vehicles. All mineral waggons are open trucks, whereas merchandise waggons may be broadly divided into the *open truck* and what is variously termed the *box van, covered waggon,* or *cupboard truck.* There is, in addition, a large assortment of specially fashioned vehicles for special purposes—namely, cattle-trucks, fish-waggons, refrigerator vans, gunpowder-vans, ballast trucks, plate-glass waggons, trucks for the conveyance of timber in long lengths [84], low-bedded trucks [81], nicknamed "crocodiles," for transport of anything abnormally high or heavy, such as boilers and machinery, and special "fender" waggons for straw hats and feathers [84]. The transportation of practically all merchandise and minerals in this country is effected by the means of vehicles—open or closed—carried on two axles and four wheels, and having doors at the side adapted to cart level. The mineral waggons [78] have, as a rule, a slightly larger capacity than those intended for merchandise, but some companies discountenance any difference, as they wish all their waggons to be interchangeable.

The standard British merchandise and mineral waggon is the ten-ton open truck (a truck being described according to its capacity and not by its tare, which is the weight of the vehicle unloaded). The open truck began with one plank at each side, which has been gradually extended, with a view to obtaining larger loads combined with greater safety, to a height of from 3 ft. to 4 ft. Closed waggons are not so popular in this country as elsewhere. There is the difficulty of getting a crane into them, unless provided with a sliding roof, which in turn is liable to admit wet; on the other hand, they obviate the necessity of sheeting. Many companies are, however, considerably increasing their stock of box vans; and the cubical contents of the new vehicles, with which the sliding roof is abandoned, are twice as large as those of the old open type of waggon.

Insulated covered waggons have recently come greatly to the fore, owing to the rapidly increasing traffic in chilled meat, fruit, and flowers from abroad. These vehicles are insulated from variations of temperature. The car body is made double, the space between being filled with a non-conducting material. Apparatus for ventilating, refrigerating, and heating, according to requirements, is also fitted. The London and North-Western Company has built hundreds of insulated waggons [82], principally for the carriage of bananas. The fruit is steam-heated in transit, so as to prevent it from ripening a bad colour.

Waggon Marks. It is customary for railway companies to give their own waggons distinctive marks. For instance, the London and North-Western mark is a white diamond, the Lancashire and Yorkshire a triangle within a circle, the North Staffordshire a Staffordshire knot, and the Great Central a star. The tarpaulin sheets of open waggons are also distinctively marked, as a safeguard against loss or theft. Thus, the Midland is a black sheet with an orange border, while the Great Western sheet is scored with crossed bars and griffin's wings. Lastly, every company has its ropes made up with differently coloured strands, though this distinction is not visible unless one of the standard ferrules affixed to each end be lost.

High-capacity versus Low-capacity Waggons. During the last few years a great controversy has raged relative to the desirability of increasing the capacity of mineral waggons. The average capacity of these vehicles is ten tons, and waggons larger than this are considered high-capacity trucks [80]. The exponents of the high-capacity waggons—a vague term, as it covers anything between fifteen and forty tons—allege, with some truth, that owing to the low-capacity system British railways are hauling considerably more dead weight, capacity for capacity, than is the case in some other countries, notably America. Their line of argument is that the adoption of high-capacity mineral waggons would considerably reduce the foregoing source of expense, and, at the same time, tend towards reducing the length of trains, because, given a uniform wheel-base, there would be fewer waggons. However, several technical difficulties stand in the way of the adoption of larger waggons. In the first place, it must be remembered that all turntables, sidings, coal drops, weigh-bridges, and pit screens at collieries, stations, and wharves are designed for the low-capacity waggon. The wholesale alteration of these appliances and accommodations would be a most costly business, while another obstacle is that in the majority of instances they do not even belong to the railway companies, but to private traders or corporate bodies, which could not be compelled to bear the expenses of the change.

Generally speaking, the traders are not enamoured of the advantages claimed for the high-capacity waggon. They fear damage to their small trucks when working with larger ones, and they scent damage to minerals while loading and being conveyed in the latter. Colliery owners carefully guard against breakage of coal, as freedom from "small" enhances its sale. There can be no doubt that there is much greater risk of breakage in loading fuel into large trucks, and also during its transit in the same. Iron ore, again, is said to be depreciated in value when carried in large trucks, for similar reasons. In the case of companies, like the Midland and North-Eastern, which prefer to own all the waggons

running over their line, and also desire to make them interchangeable, the employment of two different sizes of waggons—for merchandise and mineral traffic respectively—is deprecated.

The higher the capacity of a waggon, the longer it takes to unload, as only one checker can be employed at this end. Now, it does not much matter what length of time the unloading of minerals occupies, but the case is very different where goods are concerned, as such consignments must be dealt with expeditiously. Suppose a forty-ton truck be fully loaded with goods, it would take many hours to unload, whereas a ten-ton waggon can be disposed of within the hour. On the other hand, this loss of time would probably be met to some extent by better working. However, setting aside the question of effecting interchangeability, the crux of the problem rests on the fact that in this country there are very few cases which warrant the running of high-capacity mineral waggons—much less high-capacity merchandise waggons.

British Short-haul Conditions. A British mineral train rarely travels for a greater distance than 200 miles, and the coal consignments as a rule are comparatively small. For example, it is estimated that on the London and North-Western 80 per cent. of the coal is carried in consignments of less than 20 tons; and accordingly there would be no economy in employing 20-ton waggons for the transportation of 80 per cent. of the traffic. Nevertheless, there are some openings for high-capacity waggons. Coal passing in large quantities for locomotive use, and a regular traffic between specific points in coal, ore, or bricks, can be conveyed in 30-ton or 40-ton trucks with advantage. Several companies have built waggons of this description for those special purposes. When a waggon attains a capacity of 30 tons it must be carried on bogies [80]. To sum up, it is unlikely that the agitation in favour of high-capacity waggons will succeed as its exponents wish it to succeed, for the simple reason that the idea is based on economical conditions which do not prevail in the United Kingdom; but the movement has been of great value by demonstrating that trucks of a moderately increased capacity—namely, from 15 tons to 20 tons—are likely to ensure success, if the change can be made gradually. The North-Eastern Company now carry the major portion of their mineral traffic in four-wheeled waggons [78 and 88] having a tare weight of 9 tons 13 cwt., and capable of carrying 23 tons, while many other companies are acquiring a stock of 15-ton to 20-ton mineral waggons. These waggons fulfil a want, and confirm the fact that a paying load up to 20 tons can be carried within reasonable dimensions on two axles and four wheels, and with a tare in a ratio of only $2\frac{1}{2}$ to 1, which are results equal to anything achieved with the larger bogie waggons.

Either-side Brakes and Automatic Couplings. Returning to the technical equipment of mineral and merchandise waggons, two points remain to be noticed. First, there is the question of fitting them with either-side hand brakes (that is, brakes capable of being applied or released from either side). The Railway Employment (Prevention of Accidents) Act of 1900 empowered the Board of Trade to impose this obligation on the railways. The rule has not yet been put into operation, but in October, 1911, the Railway and Canal Commission disposed of all objections to it. Therefore, it only remains for the Board of Trade formally to "make" the rule. Meantime, the Great Western Railway has partially conformed to it, being engaged in gradually fitting its stock with the Dean-Churchward either-side brake, while the North-Western, North-Eastern, and North Staffordshire companies are likewise fitting their waggons with brakes of their own. Supposing the rule were made, a time limit of ten, fifteen, or twenty years would be allowed.

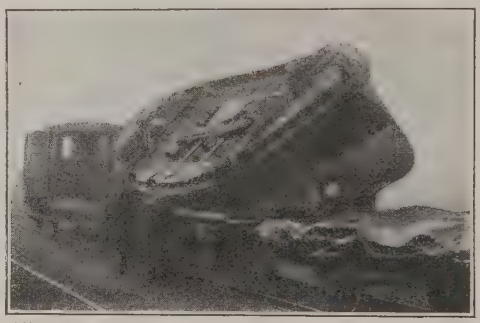
Secondly, there is the question of fitting all waggons with automatic couplers, obligatory adoption of which is also provided for by the Act of 1900. The delay in making this rule is, however, said to be due to the difficulty of finding a suitable form of coupler. Hundreds of automatic couplers have been invented and patented, but so far none appears to solve the problem to the satisfaction of the authorities. This, again, would be a very costly change, in that with automatic couplers it might be necessary to substitute central for side buffers. For the safety of shunters, the use of the coupling-pole has long been obligatory, and great dexterity is displayed in manipulating the present three-link chain couplings with it. A competition known as the "Shunters' Derby" exists, the competitors having to run down a line of waggons, coupling each one, and on the return journey uncoupling them. When the event was held at Burton-on-Trent a few years ago, the winner coupled and uncoupled twenty waggons in 1 min. $16\frac{1}{2}$ sec.

Definition of "C and D" Rates. The cardinal point of difference between the goods and passenger traffic is the very obvious fact that the former does not find its own way to and from the railway, neither does it transfer itself at junctions. In the former case there are two ways of dealing with the articles: either they are collected and delivered by the railway company, when they are charged "C and D" rates—that is, providing for the expense of collection and delivery—or they are brought to and from the terminal stations by the traders, who also undertake all loading and unloading. In the latter case "station-to-station" rates are charged, and all station-to-station consignments are carried in full truck-loads as far as possible. Cartage is provided for in two ways: a railway company either employs its own horses, vans, lorries, and men, or commissions an agent to carry out the whole of this work.

The Cartage of Goods. The staff of the cartage department comprises the following: van boys, van drivers, stablers, van washers, van mechanics, cartage superintendents or inspectors, horse managers, and veterinary surgeons. Van boys are employed only in large towns, where the police regulations do not allow vehicles to be left unattended, and goods run the risk of being stolen from the rear of the vehicle while in transit. In course of time a van boy becomes a single-horse van driver, and is subsequently promoted to the charge of pair-horse, three-horse, and four-horse teams. In certain districts, where very heavy and bulky articles have to be handled, two men are sent out with each van, so as to assist one another in lifting the weights. Some companies call the second man a "book carrier," as he is responsible for receiving moneys and getting the book signed, while his companion, the carman or driver, is in charge of the horses. Companies undertaking their own cartage give the drivers and van boys uniform caps and overcoats, in order to act as an advertisement and protect customers from fraud, while some companies compel their cartage agents to do likewise.

In London and all big towns the major portion of the "C and D" goods—that is, the orders—go through the companies' receiving offices. The staff of a receiving office comprises an agent, clerks, and porters. On the other hand, in the country consignments (as a rule) are collected to order at the consigner's premises and taken straight to the station. The employment of self-propelled vehicles in the cartage department is dealt with later.

The Care of the Horses. The carmen at small stations have to groom and stable their horses, and also to wash their vans. All this is, however, done for them at important goods depots, where the number of horses employed runs into hundreds, and the stables, in consequence, form a separate establishment. In the case of depots situated in the heart of large towns, the absolute necessity of keeping the animals near at hand compels them to be stalled on the upper floors of warehouses, in the arches of bridges, and even in subterranean labyrinths. Here there are a horse-manager, who is entrusted with the health, care, and feeding of the horses (although he does not select what horses are to pull what loads); a veterinary surgeon, with hospital staff; foremen horsekeepers, each of whom has charge of ten horses; stablers; van washers; and van mechanics, for every van is overhauled before making a journey. Moreover, at these depots there is a cartage inspector, who is a salaried official under the station-superintendent or the goods agent. It may be noted that cartage exigencies necessitate the employment of different kinds of horses at different places. Thus, in London, good trotting horses are mainly required, whereas in Liverpool strong draught horses, to pull very heavy loads at walking pace, are essential.



85. A LIFEBOAT POISED ON A RAILWAY WAGGON

Consignment of Goods. Let us now describe the procedure followed when a package or a consignment of merchandise charged at "C and D" rates is handed to a railway company for transit.

The consigner fills in a document known as a *consignment note*, in which he describes the consignment for classification rates, states who pays the cost of carriage—consigner or consignee—and signs the ordinary conditions of the Carriers' Act, printed on the back. There are special consignment notes for special kinds of consignments, such as inflammable liquids, bullion and specie, explosives, and damageable goods. On arriving at the depot, the carman drives over a weighbridge, which registers the weight of his load in bulk.

The reason for taking this weight is to furnish returns of the tonnage entering and leaving the yard, to prevent pilfering, and for the purposes of the bonus system, by which the wages of the carmen are regulated.

The Work of the Goods Staff. The articles next pass into the hands of the working goods staff, which includes the following:

INDOOR WORKING: Porters and checkers, loaders or stowers, callers-off and searchers, shed foremen, inspectors. OUTDOOR WORKING: Capstanmen, shunters, truck-markers, number-takers, yard foremen. The carman gives his consignment notes to a checker. The latter checks the address of each consignment as it is communicated to him by a caller-off during the unloading process, notes whether or not the package or article is in good condition, weighs it, enters its weight on the consignment note, and transfers it, together with the consignment note, to a porter, with instructions as to its destination and the waggon into which it is to be loaded. A goods porter wheels the consignment to the appointed section of the shed, or to where the proper waggon is standing, and here it is taken over by the loader.

The Science of Loading. There is considerable art in stowing or loading waggons. The consignments must be stowed in the sequence in which they are to be unloaded, and they must be distributed evenly over the floor, so as to ensure an even weight on the bearings, otherwise the axles might run hot. An experienced loader will stow three tons where an untrained man would find difficulty in storing 30 cwt. Further, in the case of open trucks, the goods must be packed so that when the truck is sheeted the whole erection will be ark-like in shape, thus allowing rain-water to run off. The loaders are responsible, first, for the safety, and, secondly, for the size of the loads.

Invoice System. Meantime, another checker has added the number of the waggon to the consignment note, after which it is sent up to the invoicing or "shipping" office. An invoice is then prepared, showing the forwarding and receiving stations; the number of the waggon in which the consignment is loaded; the point to which it is loaded; the route by which it is to be conveyed; the names of the consigner and consignee; the number and description of the packages, together with any marks (for some merchandise is conveyed under specific marks); the weight, showing whether carted, non-carted, or mineral; the rate per ton; the charge, whether it is "paid" or "to pay"; and any charges other than those for actual carriage, such as shippers' fees, agents' fees, etc., technically known as "paid on," if it is to be charged forward. The invoice either accompanies the goods themselves by being handed to the guard of the train that conveys it, or by being affixed to the waggon side, or it is sent by post. At any rate, the invoice is supposed to reach the receiving station—that is, the station to which the consignment is loaded—by the time the goods arrive there.

The System of Loading and Transferring. The shed foreman is really responsible for the proper loading of the waggons with safety, efficiency, and economy. He has to see that two waggons are not used where one would suffice, and that before leaving the shed each waggon is properly sheeted, doors shut, and everything safe for it to proceed on its journey. The shed foreman is the goods agent's deputy and right-hand man, but at the more important depots he has an inspector over him. The system of loading goods is as follows. When there is not a sufficient number of articles forthcoming to make up a full truck-load to one destination, a truck is fully loaded to what is termed a *transfer point*, where the goods

are re-sorted and combined so as to give good loads on to their respective destinations. On coming to a transfer point with another company, the fully loaded trucks containing heavy consignments are passed through, while the smaller consignments break bulk, and perhaps have to be carted some distance. A few of the great junctions—Crewe, for example—have tranship sheds where nothing but the work of transferring goods from train to bench and from bench to train is carried out. In the case of smaller consignments, the weight of which is too light to warrant the running of a special truck-load, the station truck system is employed. These latter trucks do not travel for long distances, and they work regularly on local goods trains which call at every station en route.

"Inwards" Traffic Methods. Having explained how the "outwards" or forwarded "C and D" traffic is dealt with, it will be understood that the procedure with the "inwards," or received, is mainly a reversal of the foregoing, with one or two refinements added. For example, immediately on the arrival of a main line train at a big depot, it is met by a "truck marker," who, from particulars supplied by the delivery office, chalks for their proper discharging berths those waggons containing "order goods" (to await orders) or full loads. Again, waggons containing goods for districts that can be more advantageously dealt with by another station, or for which forwarding instructions have been received, are also relabelled by the truck marker, thus saving unnecessary shunting and delay.

Many vexatious incidents arise to interfere with the smooth working of the traffic, and the chief of these may be classed under four heads—namely: (1) goods arriving without invoice; (2) discrepancies between the invoice and the goods actually received in the waggons; (3) invoices arriving without the goods; (4) goods accidentally trucked to the wrong position on the shed platform. Special cut-and-dried methods are applied for rectifying each of the above errors, and, in the case of the last named, the services of skilled men, known as "searchers," are requisitioned.

Arrangement of Goods Depots. The special accommodation provided for dealing with the merchandise traffic naturally varies in size and equipment according to the volume and description of the goods to be handled. In ordinary circumstances, this accommodation is situated adjacent to a passenger station, but in large towns there are distinct goods stations or depots, which, as a rule, are located as near as possible to the centres of trade and industry, although they may be some distance away from, but, of course, physically connected with, the main line of the railway company. For example, in London the City depot of the London and North-Western Railway is at Broad Street, which is reached by means of the North London Railway via Camden and Dalston; that of the Great Northern Railway at Farringdon Street; that of the Great Western at Smithfield; and that of the Midland at Whitecross Street—access to all the latter being obtained over the Metropolitan line. The peculiar accommodation set aside for goods comprises sheds, warehouses, cattle-pens, turntables, and sidings.

The arrangement of sheds and warehouses has always been a subject of controversy. No standard principles exist, for every company has evolved its own scheme as best suited to its own peculiar requirements. Broadly speaking, however, the laying out of goods accommodation must be governed by the exigencies of the three different kinds of traffic into which the question resolves itself—namely: (1) local traffic (traffic which begins or ends its journey at the station); (2) transfer traffic (traffic loaded to the station for the purpose of being transhipped into other waggons and forwarded to destination); and (3) warehouse traffic (traffic in goods which are to be stored, awaiting orders for forwarding or delivery). A shed that deals with both receiving and forwarding traffic must clear out of the former early in the day, so as to be able to dispose of the latter at night. The "rush" hours at an important goods depot are from 3 a.m. to 8 a.m., between which hours the "inward" traffic is steadily arriving, and from 6 p.m. to midnight, when the outwards traffic is being despatched. In the case of depots like Camden, where several thousands of tons have to be disposed of every twenty-four hours, one section must be completed before it is possible to tackle the other.

Lay-out of Goods Shed. A typical big goods shed consists of an array of platforms, with lines of way on each side of the ground level, and an upper floor devoted to storage or office purposes, while underneath the shed lines are capacious cellars for the storage of beer, bacon, hides, and such commodities as can be lifted or lowered direct between the cellars and the carts or railway waggons, by means of suitable cranes. It will be understood that the shed lines are used only for the loading and unloading of ordinary goods carried at "C and D" rates, which comprise all fragile or damageable articles, the mineral traffic, together with "C and D" consignments of greater weight or bulk, being dealt with in the open, where more powerful cranes can be installed. A large goods shed is mapped out so as to facilitate the work of the carmen, porters, loaders, and checkers. The walls of the cartage space bear number plates, corresponding to the numbers of the various districts into which the collecting and delivery area is divided; thus each driver knows where to station his dray. The platform pillars are hung with destination boards for the information of the goods porters and loaders, and the right waggons will be found opposite their respective boards. Lastly, to facilitate the handling of the articles, power or hand worked cranes are liberally provided on the loading and unloading platforms for both carts and railway waggons.

"Mileage" and "Running" Sidings. The lines of way in the open are divided into "mileage" sidings and "running" sidings. The former, which are arranged in pairs, with room for a roadway between each pair, are utilised for the loading and unloading of "station-to-station" consignments, together with abnormally heavy "C and D" consignments. The "running" sidings are groups of lines for shunting operations, and not for the reception or delivery of goods. All shunting is performed either by engines, hydraulic or electric capstans, horses, or gravitation, with the staff of shunters, whose grades are superior foreman, foreman shunter, shunter, and assistant shunter.

The Goods Shunter's Arduous Task. The chief yard foreman is responsible for the shunting operations, but he delegates his responsibility to the superior foreman. The latter must be an intelligent man, thoroughly conversant with the geography of the railway. His art lies in accomplishing the greatest possible amount of work in the

minimum number of movements. Shunting is arduous and dangerous work. The men are out in all weathers, and are exposed to serious risks of being run over, as not only do the trucks move up and down the parallel lines of way in a constant stream, but in many yards they are transferred from one track to another by means of turntables and lines running at right angles across the yard. Formerly, shunters were exposed to further risks by having to get between vehicles for the purpose of coupling or uncoupling them, but the obligatory provision and use of shunting-poles has obviated this. The object of shunting is, of course, to classify the outwards waggons in complete trains, to marshal them in district and station order in their trains, and to split up the inwards trains by picking out the waggons to be unloaded. The latter have then to be shunted into the goods shed or into the "mileage" sidings, where they must be properly placed for the trader to reach easily with his carts.

86. SHUNTING WITH HYDRAULIC CAPSTAN

"Dressing the Yard." In order to facilitate and economise the work of "dressing the yard," which at important centres is an operation of immense magnitude, difficulty, and costliness, schemes of marshalling sidings of elaborate construction and of great extent have been laid down.

There are three ways of laying out large shunting yards—namely, for flat, gravitation, and hump shunting respectively. Under the system of flat shunting the sidings can be laid in parallel lines, with rows of turntables across them, worked by hydraulic [86] or electric capstans. This arrangement cannot, however, be applied to the other two systems. An arrangement which lends itself to either system, and is the one most commonly in use, is to have sets of sidings in the shape of a fan or gridiron, with a neck or siding, which represents the handle, at one or both ends.

Gravitation Shunting. Gravitation shunting, of course, means that the sidings are laid with a falling gradient, utilised so as to economise power. This principle is applied in the modest siding accommodation of the wayside station, where it was practised at a very early date. Presently it was elaborated for dealing with special classes of traffic, such as loaded or empty mineral waggons, and successfully adopted in the first instance by the North-Eastern Railway for coaling ships at Jarrow-on-Tyne and for "sorting" mineral trains at Shildon. At other places, such as Darlington and the Chaddesden sidings near Derby, with the assistance of locomotives or horses, advantage has been taken of a slight gradient to accelerate the shunting, but at no place had an inclined plane been specially constructed to sort *and marshal* mixed goods traffic by gravitation alone until Mr. H. Footner, of the London and North-Western Railway projected the famous Edge Hill "gridiron" siding, on the outskirts of Liverpool. The scheme began to take shape in 1873, but nineteen years elapsed before it was brought to perfection, at an outlay of two millions.

87. CHAIN DRAG AND HOOK FOR ARRESTING RUNAWAY WAGGONS

Edge Hill "Gridiron" Sidings. The sidings are situated at the east end of the Edge Hill passenger station, north of the main lines to Manchester, the North of England, and Scotland, and have direct connections with the various goods depots in Liverpool. The main lines are crossed by over-bridges, so that trains to and from the depots are enabled to arrive and depart independently of the passenger trains which run through Edge Hill passenger station to and from Lime Street station, Liverpool. The goods depots, which are in communication with the sidings, are as follow: Alexandra and Canada Docks depots via the Bootle Branch on the north; Waterloo and Wapping goods depots by tunnels under the city to the docks, to the north and south respectively of Edge Hill station, the former also being used for the American special passenger trains to and from the Riverside station of the Mersey Docks and Harbour Board; Edge Hill goods, coal, and agricultural depots—direct; Garston Dock depot on the south.

The sidings consist of (1) the reception lines at the summit of the incline; (2) the sorting sidings, into which the waggons, when separated, first run; (3) the "gridirons," through which the trucks are filtered, so as to make them take their proper order of precedence in the train; (4) the departure lines, which receive the trains in their complete state, and where the engines are attached to take them away. On the arrival of a set of waggons in the reception lines, the rear brakes are applied, the engine is detached, and on each waggon a truck-marker chalks the number of the sorting siding it has to enter. The waggons are then let down the incline, the shunters passing the number on by hand or lamp signal to the men who have charge of the points. This process gives each sorting siding a separate train, although the waggons composing it are in indiscriminate order, but by a repetition of the operation the waggons of each train are separated in the "gridirons," whence they are lowered one by one into the departure lines in their proper sequence. The gradient of such sidings varies according to the requirements. It may begin at from 1 in 40 to 1 in 60, and finish up at from 1 in 100 to 1 in 300. Much depends, however, upon the resistance to be overcome from points, crossings, or curves. All the curves are of the same radius, so that the resistance offered by each may be the same.

Arresting Runaways. The shunters are provided with brake-sticks, which they insert between the wheel and the frame to steady the vehicles in descending, and they also use these

implements for letting down the brake-levers as required. Runaway waggons are arrested by means of a "chain-drag" apparatus [87]. This consists of a heavy iron cable, wound on a drum, which is placed in a receptacle between and below the level of the rails; a steel hook attached to the cable is fixed at the height of the waggon axle, and is worked by a lever, which also works a signal. When the line is clear for a train to pass, the hook is kept lowered; but if it is desired to stop a waggon, the hook is raised and catches the axle of the waggon, and the heavy cable being drawn out of the tank by its weight, when dragged over the ballast, so brings the runaway to a standstill. The Edge Hill yard covers an area of 200 acres, comprises 57 miles of running lines, and deals with 3000 waggons per 24 hours. The Great Northern Railway has a similar yard for the concentration of its mineral traffic at Colwick, near Nottingham.

"Hump" Shunting. "Hump" shunting was introduced into British railway practice by the Great Central Railway. It is of American origin, the idea being that where no existing gradients lend themselves to laying out elaborate marshalling yards, the necessary gradients shall be provided by the construction of artificial hillocks or "humps."

Between the years 1904-6 the Great Central Company laid out a large concentration yard at Wath, in the South Yorkshire district, the sidings being constructed with a "hump" in the middle, whence the waggons gravitate in both directions. Traffic from 45 collieries lying on every side is worked to this centre in any order, to be sorted, marshalled, and despatched in full through-train loads. Returned empties are similarly sorted out for their respective collieries. When a train has been left in the reception sidings, it is propelled to the top of the "hump" by a powerful twelve-wheeled engine, specially designed for the purpose, and from there, beginning on a falling gradient of 1 in 40, the waggons continue down the incline till they reach the level, and thence pass into the departure sidings. At Wath there are about 40 miles of sidings, and the length from one far connection to the other is 1¼ miles. The distance from the entrance of the siding to the top of the "hump" in each direction is about half a mile. As many as 5000 waggons can be dealt with at Wath in 24 hours.

The North-Eastern was the next railway company to adopt the "hump" system of shunting. This was at North Junction, York, in 1907, and other "hump" yards have since been made at Gascoigne Wood, Hull, and Newport, the two latter being mineral yards.

Views on "Hump" Shunting. An instructive debate on the respective merits of "hump" and "flat" shunting recently took place at York, under the auspices of the York (N.E.R.) Railway Lecture and Debating Society, with yard masters, foremen, guards, shunters, and others participating. The discussion revealed that those assembled were practically agreed on the following points:

(1) That "hump" shunting was a necessity if an average of more than sixty waggons per hour had to be dealt with.

(2) That for small yards a "hump" was not required.

(3) That while shunting by the "hump" method was much more expeditious than by the "flat" method, there was a greater likelihood of wrong shunts and damage occurring with the former method than with the latter.

(4) That the remedy for such mishaps was to propel the trucks to the crown of the "hump" at a speed not exceeding 1½ miles per hour, and to provide an adequate number of brakesmen or "chasers."

(5) That the increased cost of staff for a "hump" yard was more than counterbalanced by the saving in engine cost.

Immingham Yard. The largest railway yard in Europe is that laid out at Immingham Dock, Great Central Railway, which was inaugurated by the King in July, 1912. There are at Immingham Dock, in the form of running lines and sidings, some 170 miles of track, but so scientific is the lay-out that no movement is made with either loaded or empty waggons, or arriving or departing engines, that necessitates the same ground being traversed more than once. Immingham Yard is the third largest in the world.

At Immingham gradients favourable to gravitation are largely employed. For example, the high-level serving roads are so arranged. The loaded waggons gravitate thence into the sidings feeding the coal hoists, which sidings are laid on a gradient that falls at 1 in 100 towards the docks, so that the waggons complete the journey unaided. When the waggon is emptied off the waggon lift it is placed on the level of the empty waggon lines by means of an automatic tilt. The empty waggon lines fall at 1 in 75 away from the dock.

"Number-takers." Before a goods train leaves the yard the chief yard foreman is responsible for seeing that the loads of open trucks do not exceed the limits of the load gauge (a load-gauge apparatus, with swinging bar, is the safeguard), and that no timber-truck, boiler-waggon, or other vehicle furnished with ropes or chains is permitted to start without the ropes or chains being made secure and safe. In all important goods yards, and especially at junctions of any two companies, you will see officials examining the waggons and taking notes. These are the "number-takers" employed in jotting down the numbers and descriptions of all the waggons, and it is from their records that returns are made to the Railway Clearing House. Number-takers are employed by both the railway companies and the Clearing House, but some companies have discontinued the practice, or, rather, relegated the task to the guards, who enter the number of every waggon on the train in a special book.

Duties of Goods Guards. Every goods and mineral train is accompanied by a brakesman or guard, and sometimes by both, for the distinction is only one of grade, the former being a junior and the latter a senior guard. Goods guards are recruited from station porters, shunters, and so on.

Although the guard of a goods train has no luggage or parcels to attend to, he is given plenty of occupation. He has to keep a log, or journal, of his train, like the passenger guard; is responsible for the proper connection and equipment of his train, and has to see that waggons labelled for certain places are put off correctly, while at way-side stations he directs shunting operations. Except in case of emergency, the passenger guard has nothing to do with the actual working of his train, whereas the goods guard, in travelling down steep inclines, must assist the engine-driver by applying the rear hand-brake—care being taken not to skid the wheels—and, where necessary, fastening down a sufficient number of hand-brakes on the

waggons. Guards must not take on waggons loaded with goods liable to be set on fire by sparks or cinders, unless the waggons are properly sheeted. Such waggons must be placed as far as possible from the engine. Every goods guard who has used a van with a stove in it must, before leaving duty, take care that the fire in the stove is entirely extinguished, unless the van has to be sent out again immediately, in which case a small fire may be allowed to remain. Goods guards must not leave their trains until they have been delivered over to the yard foreman, relief guard, or "train meeter." As the running of goods trains is subject to some incertitude, due to the fact that this traffic yields precedence to the passenger variety, special measures are devised in order to obviate the necessity of making the guards work unduly long hours. Goods guards depots are situated at strategic centres of the line; and if a guard finds that he cannot get home within twelve working hours, he may wire to the nearest depot en route for a relief guard, and then, as soon as relieved, he may please himself whether he puts in a rest at the depot barracks or continues his homeward journey off duty. For the same purpose there is a staff of train meeters at all the principal terminal yards, the members of which relieve the guards of incoming trains, and finish up their work for them.

Limits of Load and Speed. The loads of merchandise and mineral trains are arranged according to the speed at which they are booked to travel, which, in turn, depends upon the character of the line as regards curves and gradients, and the power of the locomotives. The standard loads vary from 24 to 60 waggons. With the uninitiated, a misconception is prevalent that goods trains are worked anyhow, the only stipulation being that they do not interfere with the running of the passenger trains. As a matter of fact, the working of the goods traffic is as carefully provided for and supervised as that of the passenger, while it is infinitely harder to arrange, for the very reason that it is constantly being called upon to shunt out of the way of the faster traffic.

The "Train Control" System. A new method of operation, called the train control system, whereby the conduct of the goods and mineral traffic is ordered and regulated by telephone, was recently inaugurated, and seems likely to become general. Wherever adopted, it has effected a remarkable economic revolution in increasing the receipts from the above traffics per train-mile. The aims and objects of the system are to move the traffic from point to point as expeditiously as possible at the times required by the forwarding and receiving points; to obtain the maximum amount of work out of the locomotive power supplied, by using the fewest engines possible, by incurring the minimum of unproductive mileage, by securing the biggest workable loads, and by preventing congestion and standing time by regulating converging streams of traffic; to regulate the working of the trains so as to ensure the trainman getting a full day's work without relief or excessive hours, and to make arrangements for the prompt clearance of traffic from colliery and other sidings, and to assist the rolling stock department in the distribution and supply of waggons.

The line is divided into districts, with a control office for each district. This office is connected by a special installation of telephone circuits with every signal-box, station, and goods yard on the division; but these circuits must be inaccessible to any but the operating staff. Under what is known as the "selective" system, a call from the control office does not ring up all the bells on the line (in which case the men have to listen and count the beats until they see whether or not the signal is for them), but enables the controller to communicate direct with whichever station he requires, though there is also an additional contact for giving a general call. Further, the control office is connected with the public telephone service, so that freighters can ring up the controller, and inform him of their needs.

The Controller at Work. The controller sits at a long table, sometimes wearing a head-receiver and chest-transmitter, which allow him to receive and transmit telephone messages while leaving both hands free. In front of him is a cabinet fitted with a number of keys and switches, each of which is associated with one of the signal boxes or stations. And over the table may be suspended a "graphic train-control board"—that is, a map of the area he controls, showing not only the running lines and junctions, but also the loops, and refuge, private exchange, marshalling, storage, and loading sidings.

It will be understood that the equipment of offices varies somewhat with different control systems, but, whatever the arrangements, all aim at enabling the controller to give his orders in a manner conducive to safety and efficiency, and at furnishing him with a visual record of the position of any train at any time. The principal duty of the controller may be described in a few words. It is to "speed up" the working of the traffic within his area, so as to augment the capacity of the track, engine power, and rolling-stock. At frequent intervals the controller is advised, from every point where traffic is dealt with, of the arrival of trains, of their load, and of the amount of shunting, loading, dropping waggons, and so on, they have to perform there. He is also kept informed of the number of waggons on hand, and anticipated requirements. All such information he records on forms called *train slips*. As a rule, there is a booked service of goods and mineral trains, but it is pretty well known that such trains rarely run up to a time-table. A goods train time-table is of little value for the purpose of locating the position of the train at any time, because there are so many unknown factors in the calculation; they must give way to passenger traffic, and the amount of shunting and other work to be done differs from day to day.

The controller adjusts the actual working to passing requirements. He rearranges the work to be performed by any train, or even alters its destination. He intercepts any booked train which can be dispensed with. He orders a special to be prepared if needed. He can gauge exactly how long a train should be delayed in sidings or in loops and at signals, and if the right time be exceeded he rings up to inquire what is causing the undue delay. In short, the line may be compared to the keyboard of a piano, on which the train controller plays the tune, but it is never the same tune for any length of time.

Economies of the Control System. Everybody concerned profits by the new method of operation. The railway companies employ their engine power and rolling-stock to the greatest possible advantage, and are in a position to remove any idle time spent in sidings, and any tendency to slothful working in the yards; the freighters can rely upon not being disappointed, and greater flexibility of service, and the employees escape

excessive hours of duty, for which the knowledge at his disposal the controller can arrange for relief trainmen, and save enginemen and guards much "walking time," or waiting about. This system of working has resulted in greatly improved facilities, in particular for colliery-owners and shippers, the conditions of whose business vary from day to day, and often from hour to hour. Thus, at a moment's notice the colliery-owner can divert his consignments to another dock, or the shipper can escape paying demurrage on waggons by 'phoning the controller of the non-arrival of the vessel for which a train is in readiness. But the train controller is powerless to meddle with the signalling of the traffic, which still strictly conforms to the Board of Trade requirements. He notifies the signalmen of every alteration of working, but the latter may not suspend the absolute block system in order to speed up matters. On the other hand, the controller may at his discretion suspend certain local or Clearing House rules, relating to trainloads, brake power, and the like, but for this he accepts all responsibility. It is desirable, however, that a careful record should be kept of any control order sanctioning a breach of such rules, so that in case of accident the employee who carries it out may not be involved in any difficulty.

The faster-timed merchandise trains are composed entirely of new, large-capacity cupboard waggons, equipped with oil-boxes and an automatic continuous brake, while the most powerful express engines are employed to haul them.

Goods Rates. The charges upon a railway may be classified as rates, fares, and tolls. A rate is the cost per ton of hauling merchandise and minerals from one point to another; a fare is the cost per mile of carrying passengers in the company's own carriages from station to station; and a toll denotes "a tax or custom paid for passage," as when one company exercises running powers over the lines of another. Tolls may take, therefore, the shape of a fixed allowance per passenger, parcel, or ton of goods, or the amount may be determined by a mileage proportion of the receipts. In addition, companies are sanctioned to charge bonus mileage rates and fares for the use of special works, such as the Severn Tunnel, or Runcorn, Tay, and Forth Bridges, the construction of which entailed expenditure out of the ordinary. For instance, the Severn Tunnel is 4¼ miles long, but the Great Western Company are authorised to charge for the use of it as though it were twelve miles in length.

88. HIGH-CAPACITY MINERAL TRAIN ON THE NORTH-EASTERN RAILWAY, EQUIPPED WITH WESTINGHOUSE QUICK-ACTING CONTINUOUS BRAKE

The Midland was the first railway company to inaugurate a system of train control, and began in January, 1908. The Great Western had installed it on the Monmouthshire section, a district thickly studded with coal-pits and iron and steel works, and serving many great docks. The London and North-Western and Lancashire and Yorkshire adopted it in 1912. These two companies employ large graphic train-control boards in the control offices. The North-Eastern, North British, and Rhymney are other converts to it, the latter company having adopted a "selective" system. In every instance colliery-owners, shippers, and manufacturers are enthusiastic about this method of operation, and are co-operating with the railway companies in the matter.

Express Goods Trains. In this country the merchandise, as distinct from the mineral traffic, has ever been worked at comparatively high rates of speed, and the tendency now is to increase the speed of such trains until they fall little below that of express passenger trains. The Great Northern Railway was the pioneer of "express" goods trains, and at the time of writing boasts of giving a score of these daily, which are timed at inclusive speeds of from forty to forty-five miles per hour. A rate of speed exceeding fifty miles per hour is, however, often maintained from start to stop by trains conveying fish and other perishable consignments.

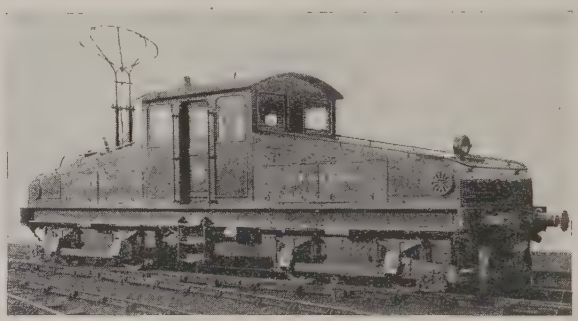
The rates, fares, and tolls to be charged upon a railway are, in a sense, regulated by Act of Parliament, and the maximum charges now authorised to British railways for the conveyance of merchandise and mineral traffic date from 1892, when, for the purpose of fixing charges, all goods liable to railway conveyance were classified under eight different heads, three of which are known as classes A, B, and C, and the remainder as classes 1 to 5. The system of classification followed still is, as it always has been, according to the weight, bulk, value, method of packing, and liability to damage of the articles. Class A traffic includes coal, coke, iron ore, and patent fuel—in short, the heavier and cheaper articles which are carried at the lowest rates, while at the other end of the scale is Class 5 traffic, which covers furniture, china, straw hats, and perfumery—in short, the more valuable or fragile articles, for which rates are naturally highest.

Important Rules. Classes A and B are applicable to consignments of four tons and upwards. In Class A the ordinary rate stipulates that the freighter shall supply trucks. If the railway company supplies trucks, an additional charge is made. In Class B the normal rate applies to traffic in railway companies' waggons, and if the freighter supplies the waggons an allowance may be made. In neither A nor B do the rates cover any labourage. Class C is applicable to consignments of

two tons and upwards, and the ordinary rate covers loading and unloading by the companies, but not cartage. Classes 1 to 5 apply to consignments of from 3 cwt. to 2 tons, and, unless otherwise provided, the rates include collection and delivery within the boundaries prescribed by the companies at the various places. Consignments not exceeding 3 cwt.—technically know as "smalls"—are charged in accordance with the regulations and scales for small parcels by merchandise trains.

The Goods Clerk's Classic. The statutory classification of goods not being considered sufficiently comprehensive, the Railway Clearing House issues a "General Railway Classification of Goods by Merchandise Trains," which has been appropriately christened the "Goods Clerk's Classic." This latter volume is published annually, and a specimen page is reproduced below.

A part of the book is printed on yellow paper, which portion contains a special classification of explosives and other dangerous goods, while there is also a private supplement on pink paper which contains instructions for the information of railway servants alone respecting the method of charging for articles of unusual length, weight, or bulk, articles requiring an exceptional truck or a special train, articles not packed or insecurely packed, any wild beast, and specie, bullion, plate, and statuary, for which the railway companies are authorised to charge "any reasonable sum they think fit." In the present statutory classification, Parliament, instead of providing for all unenumerated articles in the highest class, has placed them in Class 3, but an appeal is permissible on either side. Thus, if a freighter deems that a traffic in which he is interested be too highly placed in Class 3, he may apply to the Board of Trade to have it reduced, while, on the other hand, if the railway companies consider that its classification in Class 3 be too low, they may apply for it to be transferred into a higher class. A case in point was the successful application on the part of the companies to have gramophone records placed in Class 5.



89. ELECTRIC LOCOMOTIVE FOR GOODS TRAFFIC ON THE N.E.R.

Legal Restrictions Against Increasing Rates. Another "Railway and Canal Traffic Act," passed in 1894, renders it obligatory for the companies to prove to the satisfaction of the Railway Commissioners, if challenged, that any increase of rate made directly or indirectly since December 31st, 1892, is a reasonable increase; and for this purpose it is not sufficient to prove that the rate is within any limit fixed by Act of Parliament. The provisions of this latter Act have had the not unnatural effect of making the companies timorous of temporarily lowering during bad times what is a fair rate from fear of incurring litigation should it be subsequently restored to its original height when the depression has passed away.

In 1913 was passed a Railways Bill to carry out the pledge given to the companies by the Government at the time of the strike in August, 1911. This measure only contained one important clause, namely:

"Where on a complaint with respect to any increase (within the maximum) of any rate or charge under Section 1 of the Railway and Canal Traffic Act, 1894, the railway company proves to the satisfaction of the Railway and Canal Commissioners—

"(*a*) That there has been a rise in the cost of working the railway, resulting from improvements made by the company since the 19th of August, 1911, in the conditions of the employment of their staff (except that they may not plead increased wages to the passenger train staff); and (*b*) that the whole of the particular increase of rate or charge of which complaint is made is part of an increase made for the purpose of meeting the said rise in the cost of working; and (*c*) that the increase of rates or charges made for the purpose of meeting the rise in the cost of working is not, in the whole, greater than is reasonably required for the purpose; and (*d*) that the proportion of the increase of rates or charges allocated to the particular traffic with respect to which the complaint is made is not unreasonable, the Commissioners shall treat the increase of rate or charge as justified."

Ireland is excluded from the Bill, as the Irish railways have not accepted the conciliation scheme of 1911.

GENERAL RAILWAY CLASSIFICATION OF GOODS, 1905. 71

Iron and Steel—*continued*	Class.
Wheel Centres, *Locomotive* ..	C
In less lots than 2 tons ..	1
Wire (*iron*), not packed or wrappered	C
Wire, *iron*—Staples (of iron wire) sent with Iron Wire to be charged at the same rates as the Wire.	
Wire, *steel*—Staples (of steel wire) sent with Steel Wire to be charged at the same rates as the Wire.	1
Wire (*steel*), *not packed or wrappered*	C
Wire, *wrapped in paper, canvas, or brattice cloth,*	C
Wire Iron, *rolled in rods or coils, not packed*	C
Wire Rope, *old, cut in pieces*	B
Isinglass, *in casks or cases*	4
Isinglass, *e.o.h.p.*	5
Istle, *for Brush-making*	2
Italian or Box Irons.	3¶
Ivory Waste or Dust	2
†Ivory, *e.o.h.p.*	5
Ivory, *Vegetable, packed*....	2
" " *e.o.h.p.*....	3
Ivory Black, *in bags and casks*	*2
E.o.h.p.	2
J.	
Jackets or Mantles, *Women's (not silk), in bales, packs, or trusses*	3
Jackets or Mantles, *Women's (not silk), e.o.h.p.*.....	4
Jacks—	
Bottle	3¶
Screw, iron	1
Screw, except iron.....	3¶
Small	3¶

	Class.
Japanned Ware—	
In casks, cases, or crates ..	3¶*
E.o.h.p.	4
Japan Moss	3
Japan Wax	3
Jarrah Wood—(*see* Timber, p. 142.)	
†Jars and Bottles, *earthenware or stoneware, packed or protected by wickerwork*	1
Not packed nor protected by wickerwork, Station to Station, minimum charge as for 2 tons per waggon, exclusive of labour, Owner's risk ..	1
†Jars and Bottles, *earthenware or stoneware, e.o.h.p.*	2
Jelly or Grease, *Petroleum*	3
Jet	5
Jew's Harps	3
Jim Crows or Benders (*for rails*)	1
Jodelite Oil, *in casks or iron drums, round or tapered at one end*	1‡
E.o.h.p.	3
Joiners' Tools	3¶
Joiners' Work (*common wood*) —Beadings and Mouldings (*not gilt, lacquered, or varnished*), Doors and Door Frames, Fittings and Fixtures for Buildings, Staircases, Balusters, and Hand Rails, Window Sashes and Frames and Shutters.....	3y
Doors, Door and Window Frames, *made of Mahogany, Walnut, and other expensive Timber*	4y
Joists, *iron or steel (Bridgework)*	*Ci
Juniper Berries	3
Jute	1
Jute Waste, *not oily, for paper making, hydraulic or steam press-packed*	C§
Jute Waste, *not oily, e.o.h.p.* ..	1§

*Subject to special arrangement when of unusual length, bulk, or weight, or of exceptional bulk in proportion to weight.
† If not properly protected by packing to be only accepted at Owner's risk.
‡ Grocery List No. 1. § Paper-making Materials List. ¶ Hardware List.
ŧ Iron and Steel List. y. Reduced rate at Owner's risk.

Adjustment of Rates. In practice, the railway companies rarely avail themselves of their maximum charges. The principle of the companies is to charge what the traffic will bear —that is, rates based not on the cost of the service to the railway company, but on what it is considered the freighter can and ought to pay for it. Within their statutory maxima the companies are free to adjust their rates on a free commercial basis, subject to the foregoing provision regarding increase of rate. Thus, they may charge differential rates, in contradistinction to uniform mileage rates, but one thing they are debarred from doing is to establish a bounty system, or to give one trader undue preference over another.

As to what constitutes undue preference is, however, a very thorny question. For example, different rates charged for consignments of coal, grain, and agricultural produce carried between the same points, one for export or import and the other for home consumption, are not deemed to exhibit undue preference, as in the former case what is invariably the lower rate is considered to be justified by the much larger volume and greater regularity of consignments carried to and from the ports than between inland stations.

Machinery of the Rates Office. The head "rates office," which is entrusted with the making and keeping accounts of rates and the like, forms the busiest and most complex branch of the goods managerial department. Each district goods manager also has a "rates office," whose proceedings are regulated by the headquarters office, but which in some cases is empowered to fix local rates within the district without first referring them to headquarters. A rate-book must be kept at each station, where any trader may inspect it on demand.

The head and other important "rate offices" are subdivided into three departments—one to deal with merchandise rates, another with mineral rates, and another with live-stock rates.

Millions of rates, of course, are already in existence, while how they came to be so is best explained by recapitulating the procedure followed when a company receives an application from a trader to quote a rate between any two points not scheduled in the rate-book, and perhaps for some newly invented article which is not found in the classification book. In the latter case, the first thing to be done is to decide how the article in question should be classified.

In calculating a rate, various interests are taken into consideration—the value, nature, size, and quantity of the consignment (the quantity, whether a few tons or several trainloads, being a most important factor), cost of service, consumers' interest, producers' or manufacturers' interest, possible competition by rail or water, possible competition from other produce districts, geographical disadvantages to be overcome, and margin of profit.

Fixing Through and Competitive Rates. Through and competitive rates—that is, those rates in which more than two railways are interested—are to a large extent governed by conferences. There is the English and Scotch Conference, which explains itself; the Normanton Conference, which controls almost the whole of the competitive rates in the North not dealt with by the former; the English-Irish Conference; the Birmingham and South Staffordshire Conference; the Metropolitan Conference, and a host of minor local conferences, such as the Mersey ports.

Where only two companies are affected in the fixing of a through or competitive rate, the rates clerks meet to discuss the matter, and both companies are bound to publish the agreed rate upon the same day. The analysis of a "rate" reveals that the maximum charge which may be made is set out under two heads—namely (1) station and service terminals; (2) rate for conveyance. A station terminal is the maximum charge for the provision of buildings (including warehousing during free period) and sidings, exclusive of coal-drops; and a service terminal is the maximum charge for such labourage as loading, unloading, sheeting, and unsheeting merchandise.

The rate for conveyance is the actual cost of haulage, and this is based upon no hard-and-fast rules, although the axiom is, "The shorter the mileage, the higher the rate." At the chief rates office of a great railway company a complete record is kept of every calculated rate between any two points, and the number of rates runs into many millions. At Paddington the rates library comprises upwards of 1000 volumes.

It is a simple enough matter to ascertain from these volumes particulars about non-competitive or local rates between any two points, but none but an expert rates clerk can trace those of through and competitive rates, which are common to several companies. At headquarters a special "noting staff" of clerks is kept constantly employed entering up all new rates as they are issued, together with keyed references to the authority under which each rate was promulgated.

A separate department exists for calculating and keeping account of the passenger-train rates for parcels, and similar packages. These rates are fixed by the superintendent of the line, or, in the case of the North-Eastern and Great Northern Railways, by the chief passenger agent.

How Disputes are Settled. There is a specially organised statutory department to deal legally with the various phases of controversy between railway companies, or questions of difference between a railway company and a canal company. This is the Railway and Canal Commission, which, in addition to the above, is empowered to adjudicate upon the question of through rates over different lines where such rates would be of public benefit; to hear and determine cases instituted by the consigner or consignee of merchandise against railways in respect of excessive or preferential rates and charges, insufficient accommodation and facilities, and as to any allowance or rebate to be made from the rates charged, on the ground that the railway company did not perform terminal services; to order traffic facilities, notwithstanding existing agreements; and to apportion the expenses of erecting any improvement, such as a necessary bridge, subway, etc., between a railway company on one side and the applicants for the desired improvement on the other.

By the Act of 1888, under the powers of which the present Commission now sits, the department consists of two appointed and three ex-officio Commissioners. The Board of Trade appoints two Commissioners, one of whom must have had considerable railway experience, while the ex-officio commissioners have to be Judges of Superior Courts in England, Scotland, and Ireland. There are also a registrar and clerk to the Commission.

Drawbacks to Motor Transport of Goods. The question of the employment of mechanical road traction for the collection and

delivery of goods consignments by railway companies, as an alternative to horse-cartage, in restricted areas, is of great importance. Nevertheless, automobilism has not as yet materially affected railways where the cartage department is concerned; that is to say, it has not displaced horses to any appreciable extent in the collection and delivery of consignments carried under "C and D" rates. The chief reason for this is that, in order to render the use of self-propelled vehicles profitable, at least three factors must be present—namely, a fairly long haul, a full load of consignments for conveyance to or from a fixed point, and a clear road. Generally speaking, each of these factors is absent. Whether in country or town, the bulk of the business done consists of the cartage of goods and parcels over short distances, and through congested roads or streets, while the loads themselves are made up of miscellaneous consignments, which are collected or delivered at frequent intervals, thus entailing a great deal of waiting about. In congested thoroughfares a motor vehicle possesses little advantage in point of speed over a horse-drawn; and it is obvious that to keep expensive machinery idle, and consuming fuel and water, during a constant series of intermittent halts, must be a wasteful procedure.

Another drawback is that the same amount of work cannot be got out of self-propelled waggons as from carts and horses. A team of horses can be employed on two or three consecutive trips. There are, say, 400 vans at a goods depot: half the number can be loaded and sent out, and while they are away the remainder can be loaded up. Then, when the former return, loaded with "outwards" goods or empty, it is only a question of transferring the teams to the latter; whereas with motor vehicles the motive machinery would have to be kept idle during both the loading and unloading processes. Again, motor vehicles are not so adaptable for drawing up into what chances to be the most convenient position for loading and unloading, and there are many warehouses in which, owing to the inflammable nature of the contents, their presence is prohibited as a source of danger. Lastly, if the railway companies were to adopt mechanical traction on a large scale, they would be faced by the problems of providing stabling for the vehicles (carts can be left in the open), and of storing the petrol safely.

Advantages of the Motor Lorry. The advantages that may be claimed for the motor vehicle over the horse are: (1) Much of the time travelling to and from the stable would be saved. (2) Feeding time would be saved. (3) Greater radius of action. (4) Speed two and a half times greater. (5) Carries a greater load. (6) Will carry its maximum load up any hill. (7) No need for rest. (8) Can work 24 hours a day if necessary. The conditions under which motor vehicles can be most profitably employed are between self-contained collecting and distributing centres, and between a railway station and a town or village situated several miles apart. In the latter case, a series of passenger and goods motor vehicles has made an efficient substitute for a branch railway.

Different Types of Vehicles. The different types of motor waggons at present in use by railway companies are: steam waggons and lorries for heavy goods transport—that is, for loads of from five tons to eight tons; small steam traction-engines, coming under the Motor Car Act; petrol lorries, for light goods and parcel transport, two-ton, three-ton, and five-ton vehicles. A motor vehicle, with a carrying capacity of two tons, and fitted with steel tyres, and not costing more than £250, is considered the most suitable type for the ordinary needs of railway companies. A heavier type of vehicle, the steam motor lorry, is, however, more useful and economical when there is good loading in every direction.

Steam possesses several advantages over petrol in the heavy goods service—namely, both the initial outlay and cost of maintenance are much less; the deliveries with this class of consignment being chiefly centred at one fixed point, fuel and water are not consumed to no purpose during intermittent calls; the pace being slow, iron tyres can be used; and there exists larger reserve power for emergencies.

All technical matters relating to road motor-cars are delegated to the department of the chief mechanical engineer, while the arrangement of the services and the supervision of the staff rests with the superintendent of the line, who acts in unison with the chief goods manager in arranging the goods-car service.

Organisation and Staffing. The North-Eastern Railway has an officer attached to the chief traffic manager's department who has had a mechanical engineer's training, and he deals with everything connected with the road motors, communicating as follows: with the mechanical engineer upon mechanical matters; with the chief goods manager about goods matters; and with the chief passenger agent about passenger matters.

The Great Western Railway, which was the pioneer of the adoption of mechanical road traction for railway requirements, and which possesses the largest stock of self-propelled vehicles of every description, has organised a special motor-car department, under the ægis of the superintendent of the line, to deal with cars all over the company's system. The headquarters of the department are located at Slough, and there, too, are shops that carry out nearly all repairs. The staff of the department consists of: (1) for indoor working, a chief mechanical superintendent, an assistant mechanical superintendent, a chief clerk, a keeper of retail stores, a tyres and staff clerk, who keeps a register of the mileage of all cars, and a travelling inspector of stores; (2) for outdoor working, a foreman fitter in charge of repair shops, a foreman driver, who arranges the services, a traffic inspector, and a staff of drivers and conductors.

Selection and Training of Drivers. Much of the success of the motor vehicle depends on the drivers, and these should be recruited from the old staff of draymen, who have an intimate knowledge of the town and the conditions of the railway business. To begin with, the companies had to recruit for drivers from outside the railway service, but now they train their own drivers, and the more satisfactory drivers are the men whom they have trained themselves. Drivers are divided into four grades—namely, foremen drivers, leading driver, driver, cleaner-driver. A man is promoted foreman driver from the shops, and every important car centre is placed in charge of a foreman driver.

Candidates for the post of cleaner-driver must be from twenty to twenty-four years of age, although ex-locomotive firemen are accepted at a later age. A cleaner-driver receives a practical training in the elementary mechanism of motor traction, and when passed by the foreman he is allowed to drive one or two trips a day, to relieve an ordinary driver.

H. G. ARCHER

The Craft and Trade of Lithography. The Stone and its Metal Substitutes. Lithographic Inks. Colour-printing. Rotary Photogravure.

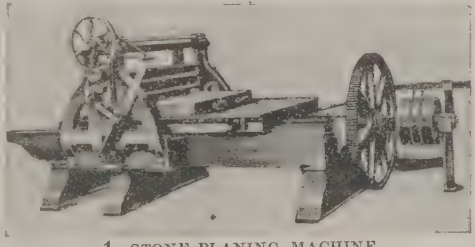
LITHOGRAPHY

LITHOGRAPHY as a business or craft is but young compared with the majority of trades, as its discovery by Alois Senefelder dates back only to 1798. It still appears but a new art to many of the older workers and to those who have intimately investigated its early stages and its early specimens.

As a craft it is one attended with so many difficulties and so many "discoveries" that it is rendered at once pleasant, as well as intricate, to all who may be engaged therein. Not only do these trying circumstances surround the man who has learnt the trade, but they come upon the amateur or novice in the way of surprises which, for some years, are very trying, not to say disheartening. The toils of the trade are not rendered any easier by the traditions which have been handed down through three or four generations of workers who learnt originally only how to work by inspection and under special guidance, without ever attempting to learn why particular methods were adopted. This has proved not only a barrier to progress, but has been the cause of preserving the use of methods and materials which ought to have been discarded at an early date—yet it is these very antiquated notions which are held in such respect by the old-fashioned craftsman.

The Trade of Lithography. From its inception as a business in London about 1818, the trade has been gradually on the increase, and at the present time no fewer than 12,000 craftsmen are directly employed in the production of lithographic prints in Great Britain alone. But although the trade is a small one, it has probably given greater pleasure to a larger number of persons than any other craft, large or small. It has been the means of preserving the works of excellent artists in a beautiful and lasting form, and this has been accomplished at a minimum of cost.

Lithography is responsible for the production of many pictures, as posters and showcards, which have given great pleasure to the whole people, and have assisted in illuminating the dark corners of our streets and otherwise unsightly hoardings. The many ways in which lithography has been brought to bear upon other printing crafts has done much to increase the production and lessen the cost of such arts as engraving and photography. As an illustrative art it has been so often and so successfully called into requisition as to make it practically indispensable to all good publications. Of course, it has had its trials, and it was many years before it ousted such processes as aquatint and mezzotint, as well as much copper and steel plate engraving, from their premier positions.



1. STONE-PLANING MACHINE

In the early days of the art it attracted some of the best artists or sketchers as a means of actually producing their own work directly upon the stone; and one artist, R. J. Lane, became an Associate of the Royal Academy through his superb productions from sketches and original productions directly upon stone.

What Lithography is. Lithography is, as its derivation implies, writing or drawing upon stone. But it has the further meaning of producing copies or prints from a stone. More recently the trade of lithography has been construed to include both printing from zinc (*zincography*) and from aluminium (*aluminography*). If a generic term can be applied, the whole of the different methods should be termed planography, as they are all, virtually, methods of printing from a flat surface or plane. The expression flat surface must be further defined as polished surface, or a grained surface, in contradistinction to a surface etched in high relief. The use of zinc as a printing surface was very little posterior to stone, but aluminium cannot be placed prior to 1890.

All three methods are generally practised by the lithographic printer; and not a few printers are also able to work the various photographic processes akin to, and including, photo-lithography and collotype. So numerous are the methods employed that a lithographic printer has at his command the means of producing any print from the roughest draft plan or specification of the architect to the finest form of imitation photograph, in black or colour. The photographic processes now applicable to lithography are so far advanced that three-colour work is practically within its available bounds.

Lithographic Stones. The stone used in lithography is an exceedingly fine, close-grained chalk or marble, geologically known as a "slate," the latter term having been applied because of the form in which it exists in quarries. These quarries are largely developed around Solenhofen, and extend many miles. But a formation of similar stone runs from Bavaria northwards into Norway and Sweden, and southwards through Switzerland, France, Italy, Spain, across by Corsica and Sardinia, into North Africa.

Formations of the same rock are known in Turkey (around Salonica), Greece, Asia Minor, and the Caucasus mountains, and stones from all these districts have been actually used. A firm in Greece has printed largely from Greek stones; another firm in Berlin has used Caucasian stone; samples from Turkey and Asia Minor have been used in England; and Spanish stone is largely used in Barcelona. French stones have had considerable patronage, but German stones are, without doubt, the finest products, and are used throughout the world: and it is estimated that in a not far distant future the supply will be exhausted. It is this fact, coupled with the cost and weight of stones, which has caused the

introduction of metal plate substitutes, and a strong attempt to compound a stone of similar qualities. The efforts in this direction have been many during the last fifty years; but the want of knowledge of the actual composition of the stone, and the inability to apply the forces which originally compressed this fine chalky mud into a durable rock, have so far been a barrier to its accomplishment.

The statement that failure in making artificial stone may be due to a want of knowledge of the constituents of lithographic slate is perhaps open to criticism. The composition is broadly that of marble, with a little something else which makes the difference—a small difference, but an important one. The original geological formation was probably in progress some hundreds of thousands of years, and the gradual consolidation of the rock was attended by such circumstances in watery surroundings, the juxtaposition of various chemicals and a heavy pressure, that the result is a stone varying in its character just so much—yet very little—from marble that, while the latter is quite useless, the lithographic slate is the only article that can be used. Like marble and chalk, it undoubtedly owes its origin to immeasurable quantities of fine shells—shells pulverised to an imponderable dust—and ultimately deposited in marine waters as a mud, to be converted finally into stone.

The Chemistry of Lithography. The actual processes of lithography, zincography, and aluminography are dependent upon chemical actions. In pursuing these methods, the chemistry of each must always be well known to the printer, for the same chemicals may not be used to attain the same object in each case.

The objects of the chemicals used may be set forth as (1) rendering the surface non-sensitive to grease; (2) rendering the surface sensitive to grease; (3) rendering the work invulnerable to decomposition by acid; (4) rendering the work easily removable by acid; (5) attacking the constituents of the ink used in drawing to make them combine with the printing surface; (6) compounding the original drawing and transferring inks; and (7) compounding the printing inks.

The foregoing brief survey naturally leads directly to a closer description of lithography in detail.

Preparation of the Stone. To obtain an original upon a stone, the stone must be ground down to a slab of equal thickness, so that both surfaces are parallel; then one surface must be ground perfectly level to receive the work. This is accomplished by grinding with sand, by the more remote hand methods, the more recent mechanical appliances [2], or by the latest device of planing the surface in a machine constructed with a long steel planing blade [1]. This machine may be said to be the most perfect appliance yet introduced for the purpose, as it can be gauged to plane off an extremely thin layer of stone, leaving a perfectly level surface all over.

After grinding or planing, the surface is burnished with a close-grained slate, until it presents a distinct, semi-glassy polish, without scratches. Upon this surface, when dry, original work may be drawn or transferred, providing the subject is executed in a line or dot. If the work is of a "grained" character, the polished stone must be suitably grained by sprinkling with fine sifted sand, and rubbing the sand evenly into the stone all over, until the surface is broken up into a fine grain. The sand is then washed off, and the work drawn upon the dry stone with specially prepared ink, called crayons.

The Inks of Lithography. By whatever method the original work is put upon a stone, the ink used must contain certain standard articles, or it is useless. The chemistry of the process starts at the very beginning, and must be kept in view at each succeeding stage. This ink must contain a fat. The fat must be compounded with other fats, solvents, and resistants to make it amenable to the draughtsman's or transferer's art. Generally the ink is compounded of tallow, palm oil, soap, wax, stearin, shellac, bitumen, and a diluent in the form of manufactured printing ink. These are not all used in one ink. Thus, the draughtsman's ink may contain tallow, wax, soap, shellac, and lampblack; the stone transferring ink, tallow, stearin, palm oil, soap, and printing ink; and the copperplate transferrer's ink may be somewhat similar to the last, with bitumen or asphalt in addition. Crayons may contain only tallow, soap, wax, and shellac. Photo-lithographic transfer ink may be similar to plate transferrer's ink without soap. The variety of the lacs is subject to variation to meet the needs of greater or less hardness, or necessity for etching. The object to be attained is to bring into contact with the stone some form of free fatty acid. It is a common knowledge that chalk—lithographic stone—when treated with an acid suffers decomposition, and some compound is the result. This is especially the case when a fatty acid attacks the stone, as the resulting compound is an insoluble salt of the calcium of the stone with the fatty acid of the ink. This compound is the real printing surface produced upon the stone. Similarly, fatty acids (as well as many other acids) attack zinc and aluminium, and in these cases produce an insoluble compound which gives the printing surface.

Etching the Stone. The work having been drawn or transferred upon the stone, the printer proceeds to obtain impressions. If the work consists of heavy masses of thick ink, it must be etched or treated with an acid that will decompose the surplus soap in the ink, and convert it into an insoluble compound with the stone. This is especially necesary with work drawn in crayon upon grained stones. The etch may be a watery solution of nitric acid, or tannic acid, or weak tea, or a mixture of gum arabic solution and nitric acid.

The older method of etching grained stones was with a very dilute solution of nitric acid in water, and it was applied in two ways. The first was to pour over, or deluge the stone with a large jug full of the etch, the whole of it running off the stone into a jug and being used again. The second was to place the stone in a rocking-trough, and fill the trough to the top edge of the stone with the etching solution. In rocking the trough, a wave of etch passed evenly over the stone and left it clear. Both these methods have the pre-eminent advantage of leaving the stone free after immersion, thus allowing the heavy bubbles of gas to escape from the surface before a second etch is begun. In either case, the applications of the etch are numerous before it is completed, and its completion is so much a matter of experience that no rules can be given. This phase of the subject is dealt with apparently in greater detail than it warrants, but it is so important in its bearings that both the principle and methods involved might be applied usefully to some present-day practices.

This treatment having been performed, the actual work on the stone is in a more or less insoluble condition in hot or cold water, and is strengthened by the etch. The work may then be

carefully inked, either by dabbing or rubbing printing ink on it with a soft, fine rag, or by rolling up with ink on a leather roller. In any case, gummy water must be kept on the stone to preserve uniform dampness and to prevent the particles of the original ink from catching upon the surface of the stone and forming a scum upon its surface. Having charged the work with ink, the stone may be washed clean.

Preparing for Printing. If the work be not drawn, or transferred, in heavy, thick masses, the first etching may be dispensed with. Such treatment also applies to work put on the stone in a hard or bituminous ink which has not had time, or does not contain sufficient active agents, to cause its ready combination with the stone, and does not require an etch. After charging with ink and washing clean, the work cannot be considered in quite such a strong condition as necessary, and it should be covered with a fine resisting powder, such as resin, talc, or silica, when it may be lightly etched with dilute nitric acid. The acid actually decomposes any remaining soap in the ink, as well as the actual stone, thereby carrying away many loose particles of grease which have come accidentally on to the surface of the stone. The stone is again washed, and well covered with gum arabic. This gum is of a complex composition, and there is little doubt that it forms a surface on the stone impenetrable to grease. Finally, after the gum has dried, it may be washed off. The work is then "cleaned" or washed out with turpentine prior to final rolling up. It is then thoroughly cleaned up by using a scraper of steel, a wooden stump with acid, or a fine stick of polishing-stone prior to printing the copies from the stone.

Printing Machinery. The printing is usually done in a machine which is fitted with damping-rollers and leather inking-rollers to imitate the the hand-press [8] method of damping a stone well. Printing is seldom taken from the original drawings. Transfers are taken from the originals and put upon new stones, so as to preserve the originals for further use. The originals themselves may be transferred to zinc or aluminium plates and stored away, thus liberating the expensive stones. Wherever possible, the originals should be drawn on the plates. The impression is procured upon paper which is carried on to the surface of the stone upon a cylinder—the cylinder being forced down upon the stone by powerful springs or weights. The action of the machine is to take the stone under damping-rollers, which moisten the surface of the stone to prevent greasy ink catching; thence under a series of inking-rollers. The stone returns under the inking-rollers, getting fed a second time, and in completing its backward journey the printing-paper is brought down upon its surface. The contact of the paper with the stone is reduced to the fine line made by a perfect cylinder coming in contact with the flat surface of the stone, the whole pressure of the powerful weights or springs being brought to bear upon this rapidly moving line of contact [5].

Lithographs in Colour. The feature of lithography which, perhaps, to the general public is the most interesting is the production of coloured prints—*chromo-lithographs*—upon paper, card, earthenware, silk, satin, and other materials. The process is difficult, owing to the great care which is necessary in every detail. An oil painting is reproduced in the following way. A tracing is taken from the picture. This tracing is generally made upon a thin sheet of gelatin, the actual tracing being done by "cutting" in the gelatin with a fine steel point. This copy takes not only the general outline of the subject, but includes the boundaries and contours of all the various colours and mixtures of colours. This *engraving* on the gelatin is then filled in with transfer ink, carefully cleaned, damped (in a special damping book), and laid down upon a perfectly clean stone. It is run through the press and transferred to the stone, to be gummed up and rolled up as ordinary work. It then constitutes the *key* or guide. From it impressions are taken upon a hard-faced paper, or paper mounted on zinc, so that there will be one impression for each colour that the artist intends to use. These impressions are dusted with an offset powder of common red chalk, or aniline, magnesia, and carbolic acid. The latter is the best, because when put upon the stone it penetrates, and the stone may be washed and polished lightly without removing the stain.

These dusted impressions are run down upon separate clean stones, and then constitute the offsets, to which the artist draws all the colours in the proper lithographic ink. When complete, they are all rolled up in the ordinary way, and the impressions in each colour are pulled, one by one, on top of each other until the whole picture is finished. The process requires great care in getting each colour to register, and in the use of colours which, by overlapping one another, give the correct colour-scheme of the original.

Transfer Processes. In the preparation of originals, the stone, zinc, or aluminium is not employed entirely for drawing directly upon. Many originals are executed upon transfer paper. The paper is prepared with a gelatinous surface compounded with an inert dust. Transfers may be taken from copper plates, steel plates, stones, or type, and patched up into the necessary design, when they are transferred to stone.

A branch of the transfer process prepares originals direct from photographic negatives in line, dot, or stipple. It is applicable to producing certain kinds of originals direct upon aluminium, zinc, and even stone. It is applied to producing work by the collotype, photo-stone, and photo-lithographic processes, little used prior to the past twenty years [see pages 5475 and 5478].

Transfers are used in all cases where a large number of prints are produced at the same time.

Metallography. There are but few methods practised in lithography which have been of spontaneous origin, and very few are in existence at the present day (1915) which were not known, although in an elementary way, by the inventor and those who practised the art in its early days, up to 1830.

The use of zinc plates was known to many in France and England before 1840, and the French lithographers asserted that the zincography of England was much better than their own because the zinc plates were manufactured so well in England. Still, zinc was not actually used to any extent until the efforts to introduce coated zinc plates, in 1885, turned the attention of lithographers to the advantages of metal plates.

Metal plates possess very distinct advantages in weight, storage, and portability which gave them a strong recommendation. But the coated plates were not perfect, and machines were not made which would give the best and most economical results. In course of time these deficiencies were overcome, and at the close of the nineteenth century the treatment of zinc had been perfected,

the use of aluminium had been adopted, and several printers' engineers had constructed rotary machines in which either zinc or aluminium plates alone could be used [3 and 10].

In mentioning aluminium, it may be noticed that it was one of the few introductions into lithography which was hitherto unknown until fully described by Bullock and Mullaby, of the United States, in 1891. The wide adoption of these metals did not come about until the perfection of rotary machines, dating from 1895 to 1900, led to the best types of these machines being brought into use from 1899 to 1906.

Although zinc had been in use by a few printers during the greater part of the last century, and various coated zinc plates came in for some patronage from 1885, it may be said that the manipulation of work upon zinc had not received the attention and study which are necessary for its successful treatment. Even at the present time there are many printers who have not used it, and those who have, hold different opinions as to the best methods to be applied.

Zinc Treatment. In describing its treatment the object will be to give methods which are known to be satisfactory and comparatively simple. The main point is to start upon zinc, without attempting to introduce the methods applicable to stone. Thus, most stone-work at the present time is executed upon polished stones, whereas zinc must always be grained. A polished zinc plate would fail to retain an even film of water upon its surface; therefore it is necessary to have it grained. It is not self-absorbent of water, as stone is, and it is not so readily affected by grease. This consideration necessitates that all new work drawn upon zinc plates must be etched first before it can be rolled or rubbed up.

The nature of the etching fluid in use forty-five years ago, or more, was a solution of gall-nuts, with gum arabic and a little phosphoric acid. This etch may still be used with very satisfactory results. But the etch which was adopted for some of the early forms of coated zinc plates has proved very successful upon plain zinc, and is that which is recommended. It is simply equal parts of solutions of gum arabic and a 5 per cent. solution of potassium bichromate. The object of this etch is not a corrosion, as popularly accepted in the term "etching," but is for a purely chemical purpose, and is actually carried out to attack the ink or crayon of the drawing and so liberate the fatty acid, to facilitate its action upon the zinc.

When the etch has been sufficiently applied, the plate may be wiped with a gum-laden sponge to remove the remnants of the etching fluid and any loose ink or crayon. Then it should be gummed over evenly with new and clean gum, using a sponge kept for the purpose. This thin, even film is to be allowed to dry, and upon its dry surface ink may be rolled evenly until the plate is quite black all over.

The next operation is to damp the inked surface, and, with clean bits of rag, to wipe off the gum and ink. When done carefully, the ink on the gum is easily removed, leaving the ink only upon the actual drawing.

The same result may be obtained in another way. If, after the etching and wiping the gum and etch off, the plate be gummed evenly and allowed to dry, the actual drawing may be washed out, or dissolved through the gum film with a solution of turpentine, beeswax, and sensitive bitumen. This solution is now very generally known as a *doctor*. After such treatment the work may be rubbed or rolled up with printing ink.

In either case, when the work has reached the stage of being covered with printing ink, it may then be dusted with talc and etched a second time with gallic acid and gum solution.

From this point the operations resemble those adopted for stone, with such exceptions as must be apparent to the craftsman in using such dissimilar surfaces as zinc, a simple metal, and lithographic stone, a complex earthy mixture.

The extensive use of zinc has created a new line of chemistry in planography, for; while nitric acid is in constant use upon stone, it is never used alone on zinc. The form in which it is used is in a very weak solution with water and alum. This solution, also the outcome of one of the best workers upon zinc before 1890, is now generally known as the *acid-alum solution*. Its characteristics have earned for it a very extensive adoption, not confined merely to zinc, but applicable also to stone and to aluminium.

Concurrently, the use of acids upon metals has caused the much more general use of a simple corrective, in powdered whiting, rubbed on the surface gently with a little water to neutralise the acid.

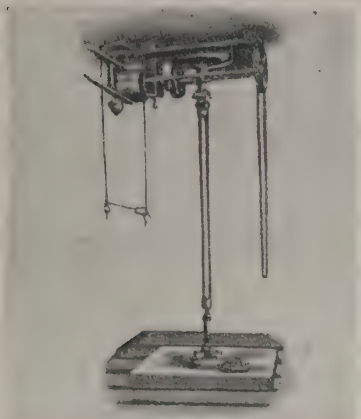
Take as a pointed example the operation of removing work from a zinc plate, that it may be replaced by a corrected drawing. The plate is well rolled up and dusted with talc, gummed evenly and thinly. Upon the part which is to be removed is dabbed or painted a solution of caustic soda or caustic potash. This penetrates the gum and destroys the greasy drawing on the plate; and to prevent other parts of the work being damaged, the caustic soda is removed quickly, with a sponge well filled with water. The work having been taken out, the area so cleared must be cleaned to take new work. This sensitising or cleaning is effected with sulphuric acid, which, having been carefully applied to the area, is washed off and immediately followed with the whiting treatment. The necessity for this arises through the well-known action of the acids in dissolving or thickening all the work over which such acids have acted. The whiting neutralises the acid action.

The craftsman who has only used lithographic stone will recognise at once how differently zinc has to be treated, and the difference is still more apparent when aluminium is used.

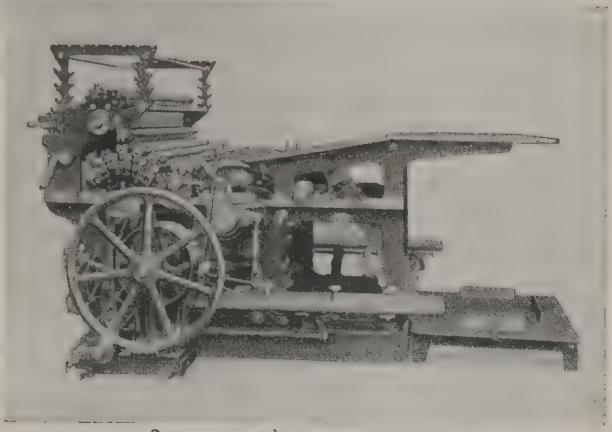
Aluminium Treatment. When original work has been drawn upon aluminium, the first operation in printing from it is to dust it with talc and etch with phosphoric acid and gum. This etch is wiped over carefully and finally wiped off, to be replaced with an even, thin film of gum. When this has dried, the work is washed out, through the dry gum, with a "doctor" solution. After this has evaporated to dryness, it is washed off with gummy water, and the work is rubbed or rolled up with stiff ink, dusted with talc, and etched again with a second application of phosphoric acid and gum.

The great question of retaining a film of moisture upon both zinc and aluminium plates so that it shall be sufficient to prevent ink catching at any parts where it is not wanted, and at the same time not so excessive as to prevent the proper rolling up of the work, has given rise to several methods of treatment, or, rather, to the invention of several solutions having for their object the retention of a hygroscopic film upon the plate. These solutions are known by special names, such as Roderzone, the Tutzschke etch, and as "dopes." Each of

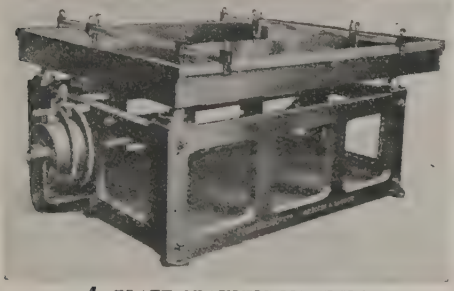
THE MACHINERY OF THE LITHOGRAPHER



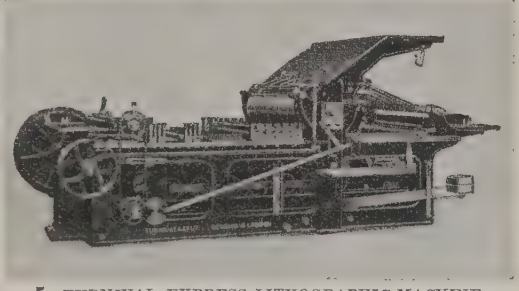
2. GRINDING & POLISHING MACHINE



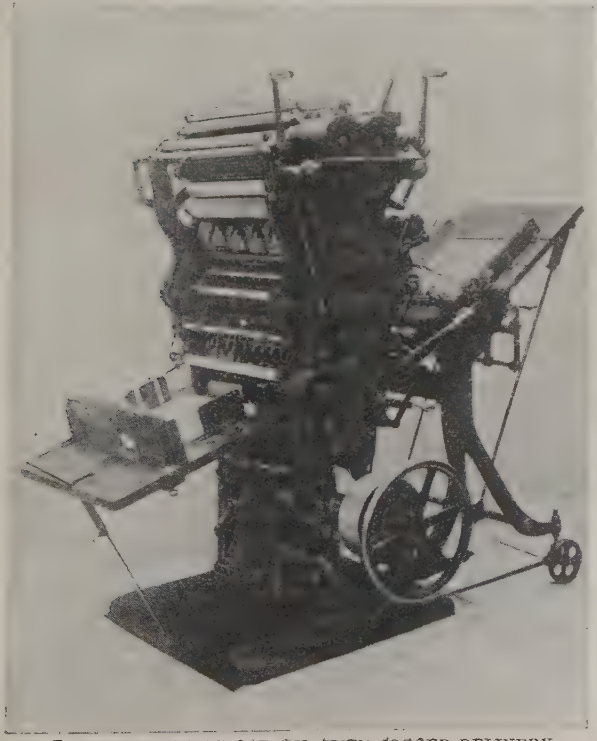
3. FURNIVAL'S DIRECT ROTARY



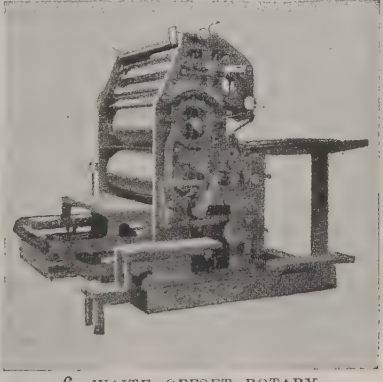
4. PLATE-GRAINING MACHINE



5. FURNIVAL EXPRESS LITHOGRAPHIC MACHINE



7. HARRIS OFFSET ROTARY, WITH JOGGER DELIVERY



6. WAITE OFFSET ROTARY

8. MODERN TOP-LEVER HAND-PRESS

these may be used instead of the second etch, both for zinc and aluminium.

For those who essay to work on either metal, it is a good plan to use these special mixtures until by practice they can overcome the difficulties in other ways.

As a comparison of methods, it may be advisable briefly to describe how work may be removed from aluminium and replaced by new work. The whole of the work must be rolled up in stiff ink and dusted with talc The work is removed by concentrated sulphuric acid, applied carefully with a quill or glass brush. The area is well washed with clean water, and the whiting treatment applied The new work may be drawn or transferred in.

The Choice of Metals. The outline of the treatment of zinc and aluminium here given is in many cases all that is sufficient to the experienced lithographer. It is practically impossible within the limits of this work to enter into every detail of printing from metals—such a description is only possible in a book devoted wholly to the one subject. There are, however, still points of interest and importance appertaining to the subject which can be added.

To those who have never used zinc or aluminium, the question may naturally occur as to which is the better metal for general use. The expert upon aluminium may contend that it is the better metal, and for some few purposes that contention may doubtless be true. For general use, however, zinc possesses all the qualities requisite for good printing.

Aluminium is much lighter in weight and colour than zinc; it is not so brittle, but expands more by heat than zinc. The grain obtained upon its surface is sharper, and is more suitable for very fine direct photographic work than that of zinc. But in the main its general treatment is much more removed from the treatment of stone than is zinc. The use of zinc is better understood, and in the hands of a careful craftsman will yield results equal to aluminium.

Advantages of Metal over Stone. Both metals are more limited in treatment than stone, but the fact that metal plates can be clamped round cylinders and printed from at a greatly increased speed has given them an inestimable advantage over stone.

Although the flat-bed lithographic printing machine has been constructed to run at 1000 or even 1200 impressions per hour for the last 25 years, it has only been in a few cases, and possibly only upon special work, that such a speed has been maintained for nine months out of the year. The rotary machines of 1898–1900 were constructed for 1500 to 1800 impressions per hour, and the minimum speed of 1000 has been easily maintained. The economy in the cost of metal plates compared with stone, the readiness of handling plates, and the speed obtainable by rotary machines have been potent factors in the adoption of metal plates.

To some extent, the use of metal plates has revived the execution of work in crayon, because the plates are grained, and in most ways are suitable for that class of work. It has been through the agency of plates and rotary machines that vast numbers of posters have been produced at comparatively low cost, but it has not been in all cases that poster-printers have forsaken the use of stones. They are still largely used, owing to the special features of stone, which lend themselves so much better to the manipulation of the artist.

A Plate-graining Machine. The second advent of printing from metal plates has been accompanied by changes in trade practice, in cost, and in the introduction of machinery. Hitherto, zinc plates were all grained by hand. The coated plates, introduced since 1885, were in some cases grained by sand-blast; but when the great use of metal plates became apparent, an old form of stone-grinding machine was remodelled, and appeared as a mechanical graining machine [4]. This is a large, water-tight trough, supported upon spherical bearings or moved by cams, so that it executes a short circular movement, similar to the hand method of graining with a muller The plate is placed in the trough, and covered thickly with balls of wood, glass, or porcelain, upon which may be sifted the graining sand, and water sprinkled all over the whole. The motion of the trough is imitated to some extent by the balls, which travel very slowly, owing to their crowded condition, and by their motion press the sand upon the plate and grain it. The economy of this machine has made it indispensable to any large user of metal plates.

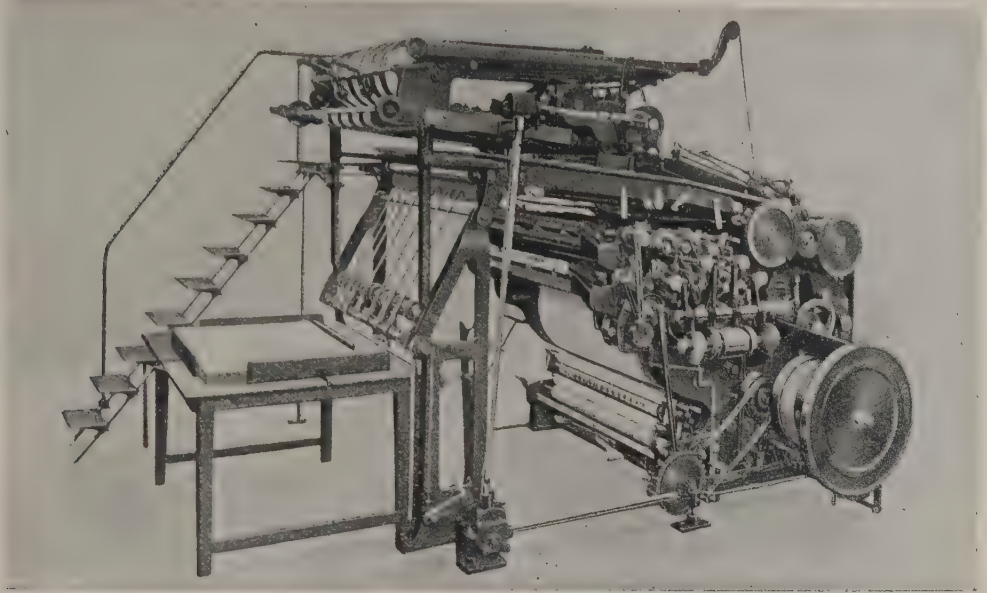
Lithographic Printing Machines. For printing from metal plates, practically all the printers' engineers in Great Britain, the United States, Germany, France, and Italy made excellent machines. The new conditions of printing from metal brought about the perfection of the damping apparatus, and introduced changes in the gearing of the inking-rollers. Indiarubber rollers were tried for these machines, and ultimately abandoned; the construction was made to meet the necessity of the closest register of colour-work; and in this direction many examples from the United States and Canada showed how perfect the machines had become.

The rotary principle had been attempted in 1842, and had gone through various stages of development in a spasmodic way all through the century. In 1886 it was placed upon a sound footing by T. Ruddiman Johnston's machine, and with numerous other machines from year to year it culminated in 1899 in the well-built rotary of the Aluminium Plate and Press Company of New York. Thenceforward the rotary principle was established, and was to see unheard-of adaptation.

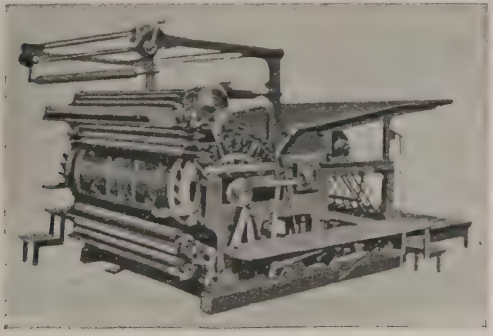
At the Printing Trades Exhibition of 1904, George Mann & Co. showed a rotary machine for tinplate printing, which, as a novelty, was one of the most unexpected inventions; but it has gone on and has been successfully adopted by many printers The principle of the tinplate printing machine lies in the fact that the original metal plate is caused to print upon a rubber-covered cylinder, and this cylinder yields its impression to the tinplate which is brought into contact with it. Tinplate printing was not new in 1904; it had been in vogue in one way or another since 1875, and had passed through many stages of improvement. The principle of printing from an elastic surface had also been adopted in those earlier days; and there is little doubt that some printers had used such machines for printing upon thick pulp and other boards, on fabrics, and the like. But no one seems to have suggested using such a machine for printing upon thin papers in the ordinary course of business.

Offset Printing Process. Such an adaptation was conceived by Ira W. Rubel in the United States in 1906, as the result of a common incident in lithographic printing. He was watching printing in a machine, when the feeder failed to place a sheet of paper in position, and the impression was printed upon the cylinder. The next sheet of

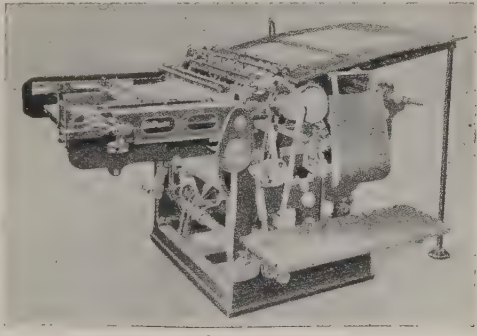
FINE EXAMPLES OF LITHOGRAPHIC PRESSES



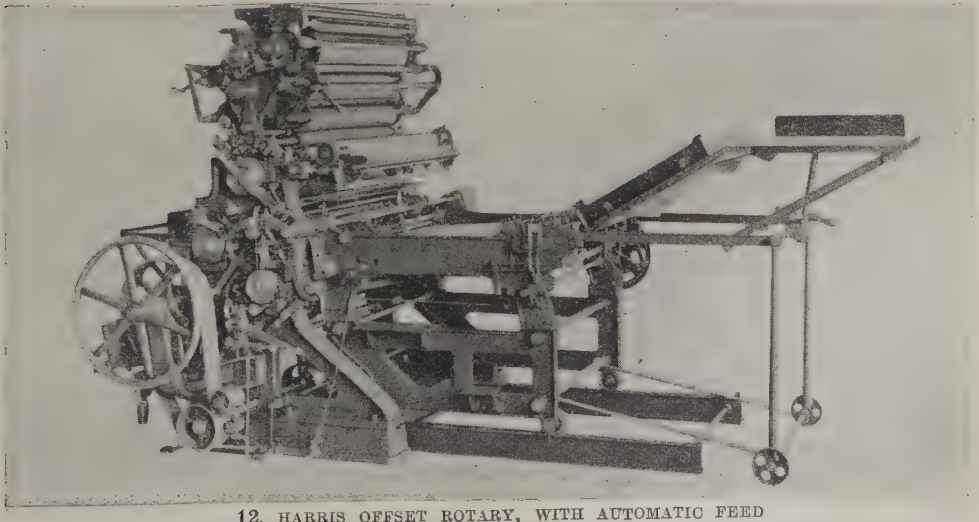
9. MANN'S TWO-COLOUR AND PERFECTING OFFSET ROTARY MACHINE, WITH AUTOMATIC FEED



10. LINOTYPE LITHO ROTARY PRESS



11. MANN'S OFFSET ROTARY



12. HARRIS OFFSET ROTARY, WITH AUTOMATIC FEED

D 73 5729

paper received this impression upon its back from the cylinder, as well as on its front from the stone. But the impression on the back was interesting because it was so perfect, although printed upon the wrong, or rougher, side of the paper. It gave rise to contemplation, and during 1906 Rubel had a machine built to print by offset—that is, to introduce a rubber-covered roller to receive the first impression and transfer or set it off upon paper brought in contact with this rubber cylinder. To those outside the trade this might have appeared somewhat unnecessary, but in the trade the principle was soon recognised and appreciated. The largest amount of lithographic printing is the production of business letter-paper and similar commercial paper. In addition, there is a very large production of share certificates and similar company papers, all of which are executed upon hard papers, many of them hand-made. The printing upon these papers has always been difficult, especially when it is stipulated that the paper shall not be damped. It was in this direction alone that the offset method would prove of incalculable value, and it was for this class of work that it was first used. In fact, printers themselves were apt to say it was only applicable to that work. Time has proved to the contrary.

Advantages of the Offset Method. The new method opened a new channel for planographic printing. Hitherto, lithography had been unable to print upon the rough papers used in letterpress printing, but by this offset method it has become possible to print upon any surface and any thickness of paper. It has gone beyond the limits of letterpress printing, in the accomplished fact that fine photographic process-work can be printed equally well upon rough paper with a result so soft that it loses the mechanical cross-line or screen, and emerges into a collotype or photogravure effect. It has widened the range of lithographic work, and created a new phase of the process; and concurrently it has generated a public taste for the evenness of its products, which seldom have the appearance of being overloaded with ink.

For colour-work it has proved perfectly satisfactory, and has led printers' engineers into building machines of increased capacity, such as have not been possible in either flat-bed or direct rotary printing machines. Perhaps the greatest advantage of offset printing is in the increased speed. No machine is built with a lower capacity than 1500 per hour; the machine suitable for all classes of work can be run at 2500 per hour; and machines for some classes of work may be run at from 3000 to 6000 per hour by using an automatic feeder [12].

The application of the offset method to commercial printing, much of which is transferred from engraved plates, soon led to the production of tone engravings by the intaglio rather than the relief method, in order that transfers could be taken from the plates by lithographers, and transferred for offset printing. At the same time great attention was given to photography, to obtain direct tone photographic process-work upon the plates.

It may be said that every known method of printing has been tried by it, and in very few cases has it not fully justified the experiment. Some printers have used it for work usually printed by letterpress machines, because of its speed, coupled with the economy of lithographic transferring as compared with stereo- or electro-typing.

Offset Machines. The offset machines now in use are of three distinct types: (1) The American pattern in which the printed sheets are delivered low down, almost on the floor; (2) American and German machines where the delivery is direct from the printing cylinder upon a board raised about two feet from the floor; (3) British and German machines in which the delivery is high, and immediately under the inspection of the attendant [11]. Some British, French, and German machines have been built on the American type.

The machines are now being manufactured by Messrs. R. Hoe & Co., Walter Scott, Potter, Hall, Kellogg, and Harris in America; G. Mann & Co., Waite & Savill, Furnival & Co., and Linotype and Machinery Ltd. in Great Britain; Voirin in Paris; and by Albert, Mailänder, and the Vogtland Company in Germany. In addition, Messrs. Eyre & Co. of Manchester make the necessary parts whereby flat-bed machines may be converted into offset machines. Messrs. Ratcliff & Sons of Leeds make flat-bed offset machines, and convert similar machines. So great has been the adoption of the two latter machines that it has prevented a very extensive sale of the rotary offset machine in Great Britain; but in America the Harris [7-12] and Potter offset rotary machines have been largely adopted, and there are few firms without them. In Great Britain the Mann offset rotary [11] has been well patronised; so, too, has the Waite & Savill [6]. A few American machines have been installed.

In addition to the single-colour offset rotary, Messrs. Geo. Mann & Co. have made a two-colour machine, and a machine to print from the roll or web [9]. Voirin of Paris has made similar machines, and Albert of Frankenthal has made a two-colour machine. In all these machines, except the three in the third group, the plate cylinder, with its inking and damping apparatus is at the top. In the other three machines the plate cylinder is hung low, and the inking and damping are at a convenient level for easy inspection.

After these machines had been in use for some time, presses were constructed for reversing transfers and proving work for offset printing. Of these there are at least four—the Fuchs & Lang, the Mann, the Reverso, and the Wogden. The last-named is exceptional, as it is capable of use as a lithographic printing machine.

"Printex" Transfers. Of the photographic methods which have been introduced as aids to lithographers, the "Printex" takes a premier position. For economy it is customary to use large stones or plates, and transfer upon them a large number of the same subject, whether in black only or in colours. To set up the transfers accurately by hand a considerable amount of time and dexterity is necessary. It is to save this that the "Printex" method was invented. The process is photographic and mechanical. The photographic operation is by far the more important, and with the mechanism for its accomplishment constitutes the basis of the invention. A diapositive or transparency of the subject is made, and placed in a special camera. The design is focussed upon a large sheet of glass which has been sensitised. This glass is placed in a rigid frame which can be accurately moved horizontally or vertically any required distance. Therefore, when all adjustments have been made, a series of exposures is carried out at regular intervals all over the plate, and gives a negative plate. This is ultimately placed upon a sensitive zinc or aluminium plate, and by one exposure the whole series of the design is printed on the plate, thus making a printing-plate ready for printing in the machine.

The accuracy of the method has led to its application to the production of cylinders and plates in relief and in intaglio for postage-stamp printing.

True to Scale or Vandyke Process. In many cases where a few copies of a drawing, such as engineers' and architects' designs and plans, are required, the ordinary blue-print or ferro-prussiate copy is satisfactory. But when the quantity is large such method is too expensive, and can be displaced by the more permanent method practised by Vandyke—an Englishman, with long experience in a Government printing-office in India. Like other methods adopted for a single purpose, it has been found useful for other purposes in which copies are desired of any subject made up of lines or dots.

Somewhat similar in principle to blue-prints, it is worked out upon a negative basis in its early stages, but assumes the positive character in its final result. The method, though apparently simple, must be carried out with every care in each detail if a really good result be required.

The process is direct photography upon a metal plate, which can then be used to print any number of copies. Any line-drawing or print, which is upon paper, the back of which is perfectly clean, may be placed upon a sheet of sensitised zinc or aluminium, pressed into absolute contact in a strong photographic printing-frame or a pneumatic frame, and exposed to light. According to the thickness or opacity of the paper, the exposure will also vary. Its actual duration should be measured by an actinometer. The effect of the exposure will be that all the clear paper will be printed upon the sensitive film, and the drawing will not be printed—in the photographic sense. The plate may then be flooded with water to remove the sensitiser from the film not acted upon by light, and treated with an aniline colour solution which stains the remaining film darker than the lines of the subject, and proves whether the exposure has been sufficiently accurate to proceed further with the plate. The plate is then treated with weak ammonia, and, after drying, is soaked in water, where it is gently rubbed with cotton-wool to remove the unexposed film. The plate is dried, and rubbed carefully with pumice-powder, and finished with whiting. This cleans the plate where the drawing prevented actinic action.

The subject is next treated with a strong bituminous, greasy ink, and allowed to stand for an hour. The plate may then be treated with weak hydrochloric acid to dissolve the exposed film, thus leaving the subject covered with ink, to be treated as an original upon metal.

Direct Photo-lithography. Of all the attempts to produce originals directly upon stone or plate, none have given better results than the work of Frey, of Zürich. His method is largely a personal one, assisted by photography. The photograph—or a set of three-colour photographic negatives may be taken—is printed upon a series of sensitised stones or plates. The sensitive film is probably bituminous, and can be dissolved by suitable solvents. It is at this point that the art is applied, as, after the photograph is printed, the artist dissolves such parts as are not required for that particular colour-plate. All the colour-plates are made up by the same method, but in some cases large areas are dissolved, in order that the artist may add work of a particular character to help the production. Pictures executed in this manner are the most realistic imitations of water-colour drawings ever produced, especially when printed by the offset method upon Whatman or similar paper.

Rotary Photogravure. In the routine of the lithographer, he is called upon to print from engraved copperplates—aquatint or mezzotint plates, etchings and photogravure. It is not therefore out of place to add a short account of the latest form which photogravure has assumed. In the past, the popular conception of photogravure was based upon the method of Talbot and improved by Carl Klic. It is almost entirely a photographic process, as will be seen by reference to the description in the section devoted to Photo-Engraving. To assist in following the later development, that article should be perused.

It will be seen that to produce an intaglio plate from which prints can be taken it is necessary to retain a granulated surface on the plate, while the actual picture is sunk or etched into the plate through the interstices of the grain. For the true photogravure, which is printed by hand methods, a bituminous dust will create a satisfactory grain, but for machine printing it does not prove effective. In printing by machine, the picture is etched upon a copper cylinder, the cylinder revolves in a trough of very thin ink, and is scraped or shaved clean, upon the parts not carrying the picture, by a knife or docteur. The paper is brought into contact, and prints are obtained at 1000 to 3000 per hour.

To secure this result, the granulation of the surface of the cylinder must be most perfect, and is obtained by printing photographically a black cross-line screen of about 130 lines to the inch upon that carbon tissue which has upon it the final negative picture, and is to be fastened on the copper cylinder as a resist for the final etching into the cylinder. It is by this means that in Germany, as long ago as 1904, newspapers were illustrated by photogravure. Since 1910 the method has considerably increased, and several engineers have constructed suitable machines, the latest of which is a British-made machine which prints two colours on one side of the web, and one colour on the other side, at one operation. The actual German patent was revoked in July, 1914, and the method is now growing into great favour. From early in 1914 a Southend weekly paper has had the last page printed in photogravure—this printing taking place at the same time as and at the same speed as the printing of the letterpress matter on the remainder of the paper. Whole magazines have been printed in the same way, including the type-matter; a section of the "Illustrated London News" has been printed by it since the autumn of 1912; the SELF-EDUCATOR contains work by this method [see frontispiece to page 4085], and catalogues of the highest quality are specimens of such work.

Progress of the Lithographic Trade. In concluding this summary, it may be said that in the ordinary way of business the lithographic trade has greatly improved. This is largely due to the offset process, and the more perfect application of photography which this process has rendered possible.

The applications of planographic printing are both beautiful and numerous. The well-known oleographs of forty years ago, and their continuation at intervals during the later period, the artistic and fancy Christmas-cards, illustrated toy books, atlases, natural history plates, representations of objects of art (pottery, silver, iron, fabrics), catalogues, and artistic publications, owe their value and charm to this business, a craft which is not of an ephemeral character and is not an amateur one, but one which requires many years of steady application to learn and carry out successfully.

CHARLES HARRAP

The Methods of Ascertaining and Stating the Quantities of the Various Classes of Material and Labour in Building Work

THE QUANTITY SURVEYOR

QUANTITY surveying is a process in building enterprise which comes, in point of time, between the preparation of the drawings and specification by the architect and the making of an estimate by the builder. A bill of quantities purports to set out, in the terms usually employed in the building trade, the quantity of materials and labour which will have to be supplied, and, generally, the services which must be rendered in erecting and completing a particular building for which tenders are desired.

Qualifications. To make a successful quantity surveyor the qualities of character requisite are a love of accuracy and thoroughness and what may be termed intelligent doggedness; intellectually, a taste for analysis, for calculation, for construction, and for mechanical contrivance. The young man who hopes to attain his results by brilliant dashes has no place here.

The general education which must precede technical training includes clearness and neatness in writing—especially in the making of figures—the ability to write English with precision and distinctness, a thorough knowledge of arithmetic and mensuration, and a firm grasp of elementary mathematics, including plane and solid geometry—as taught at South Kensington—some familiarity with mechanical and—if possible—freehand drawing, and bookkeeping. With this equipment a lad of 16 or 17 will be ready to begin the study of the technical work of quantity surveying.

Squaring. Measurements in a quantity surveyor's office are calculated in duodecimals, and the first work he would there be put to is what is known as "squaring dimensions." An example follows:

EXAMPLE OF SQUARING DIMENSIONS

	31 0 24 0 6			12/	10 0 7 4 24		
		587 0	Excavate general surface not exceeding 6' 0" deep and throw out			16 11	Fir framed in floors
			and Fill earth into carts and cart away	1·2/2/	5 6 5 3	91 0	2" deal moulded casements, with cross bars and hung at bottom
	153 4 2 0						
	5 0	421 8	2 B in mortar	2·6/	14 6	145 0	4½" × 3" fir wrought all round and framed, rebated, and twice beaded frame
		9 10	Render float and set on brick walls	4·3/	3 7 2 8		
	4 0					66 10·8	1" steel
	8 0						
		37 8	Cube brickwork in mortar		3 2 1 4		
24	6 0					2 10·8	Planing on steel
2/3·7	No 5	144 0	Rough cut birdsmouth				
		100	Ends of timbers cut and pinned				

Of the three columns on the left hand side of the paper the middle one is for the actual measurements, or "dimensions," which are known as "cubes" (*i.e.*, solids), "supers" (*i.e.*, areas), "runs" (*i.e.*, lineal measurements), and "numbers." The column on the left is for "timesing" (*i.e.*, multiplying); in the column on the right are put down the results of the "squaring." The result is usually calculated to one place of duodecimals; if any remainder fall short of 6 it is neglected; if 6 or over, a unit is added. In some cases, as in measurements of steel, iron or copper, the squaring is carried to two places. The third item given above is a semicircle of 5 ft. diameter, its superficial area being set down in the third column. The next item represents a solid mass semicircular on plan and 6 ft. deep; in the third column is its cubical content. The process of "timesing" is as follows: "2/" means twice; "3/2/" means first multiplied by two and then by three, or six times; "1·3/2/" means multiplied by two, and then by three *plus* 1 (or four)—*i.e.*, 8 times. The figure "1" is said to be "dotted on"; "$3/\frac{2}{1}/$" means three times three, or nine times. The student will do well to practise squaring dimensions (which he can easily invent) until he becomes proficient.

Abstracting. The next process in the work is "abstracting," somewhat analogous to "posting" in bookkeeping from the day-book to the ledger, and consists in transferring the results of the "squaring," together with the descriptions of all the items on the columns of dimensions, to the sheets of abstract, at the same time arranging them under the various trades to which they belong, and in the order in which they are finally to appear in the bill. Abstract paper is usually ruled as shown in the illustration, the vertical lines being rather less than an inch apart. Sometimes these lines are made by folding the paper. The chief difficulty in abstracting is in the "setting-out"—that is, in judging of the amount of space to leave for the different items. It will be readily understood that quantities of the same item occur many times in different parts of the sheets of dimensions, and one of the objects of abstracting is to collect them so as to form one item in the bill. Example of abstracting:

EXAMPLE OF ABSTRACTING

Bricklayer.

Reduced Brickwork in Mortar

	Cube	1 B	1½ B
	420·0	100·0	60·2
	78·8	45·9	170·8
		1,740·2	39·7
	445·0	560·4	720·4
	50·6	880·5	970·0
	395·6	3,126·9	1,551·3
	44·3	570·10	445·3
	354·3	2,930·10	1,506·4
Less ½rt =		936·7	354·3
		1,873·3	1,872·3
		3,733·10 = 13 rods 106 feet.	

Plasterer.

	Cube	1 B	1½ B
	50·0	45·0	113·11
		120·6	40·10
		30·9	29·6
		240·7	270·0
		520·10	445·3

Joiner.

9" × 11" deal moulded skirting and backings

150 0 — Fitted ends

5 — Internal mitred

6 — External mitres

6· — Returned and mitred ends

2·

11" deal moulded and square fixed framing two panels high

50·0 — Extra on ditto for part formed as door, 2' 6" × 6' 6", including the requisite splayed and rounded fillets mitred round as stop and fixed with screws

4·

Less ½rt =

The only dimensions that sometimes undergo a change in their way to the abstract are those of brickwork. In the usual or "London" system of measurement, brickwork is reckoned in superficial "rods" (*i.e.*, 272 ft.), reduced to a thickness of 1½ brick, and the items are abstracted in a way to facilitate this. Thus 500 ft. super. of 2 B (*i.e.*, wall 2 bricks, or 18 in. thick) would be abstracted as 1,000.0 under the head of 1 B; 500.0 of 3 B, as 1,000.0 under 1½ B; 500.0 of 2½ B as 500.0 under 1 B, and 500.0 under 1½ B; 500.0 of 2¼ B as 500.0 under 1½ B, and 250.0 under 1½ B; and so on. When the columns have been added up, and the deductions subtracted, the total of 1B is "reduced" to 1½ B

by deducting one-third (or multiplying by two and dividing by three), the result is then added to the 1½ B, and the sum divided by 272. Expertness in abstracting can be attained only by practice. The following general maxims, however, may usefully be borne in mind. Do not be afraid to use plenty of paper. Be careful to put the figures exactly under those to which they will have to be added. Do not take any liberties with the dimensions. Abstract the descriptions precisely as they are given by the taker-off, and, above all, do not use any abbreviations of your own invention. Abstract all notes and memoranda as carefully as any of the dimensions. As each item is abstracted a vertical line is drawn through it on the sheet of dimensions. The abstracts are then checked, the items thereon being ticked in red, and the corresponding items in the dimensions cut through in red. This done, the abstracts are "made up"—that is, the columns of figures are cast, deductions abstracted, and then results brought into superficial yards, cubic yards, cwts., qrs., and lb., etc., as the case may be. This work, for the sake of clearness, is commonly done in violet and checked in red, or done in red and checked in black.

Billing. Billing consists in taking from the abstracts, when prepared as above described, the various items thereon and throwing them into the form of bills ready for pricing. The following is a usual order of bills. No. 1, Preliminary. This bill consists of general items not susceptible of measurement and not belonging to any particular trade, and yet important to be borne in mind as forming an element of cost—for example, provision of water for the works, sheds and latrines for workmen, office for the clerk of works, insurance from fire and making good after that or any other accident, keeping the building in repair for a stipulated time after completion, risks and expenses under the Employers' Liability and National Insurance Acts, and other matters extracted from the contract and the preliminary clauses of the specification.

No. 2, Excavator and Concretor; No. 3, Bricklayer and drains; No. 4, Mason; No. 5, Tiler (or Slater) and Slate Mason; No. 6, Carpenter; No. 7, Joiner and Ironmonger; No. 8, Plasterer; No. 9, Founder and Smith, Gasfitter (or Electric Lighting Engineer), Bellhanger, Hot-water Engineer; No. 10, Plumber; No. 11, Glazier; No. 12, Painter and Paperhanger; No. 13, Summary.

At the head of each bill are put the general clauses from the specification touching the labour and materials proper to the trade—for instance, the nature and quality of the bricks, stone, slates, timber, steel, etc., the composition of the concrete and of the mortar, the bond of the brickwork, the gauge of the slating and the like. Of the order of the items in the various bills it is not possible to give more than a general account. Suffice it to say that, usually, "cubes" come first, then "supers," "runs," and "numbers." Within these divisions the order followed is, generally speaking, that of increasing value.

Taking-off. We now come to "taking-off," or the measurement of builders' work from the drawings and specification prepared by the architect. Here it is that the chief work of the quantity surveyor is found, and on his excellence in this will his standing in his profession rest. During the whole of the time the student is engaged in the subordinate class of work already described he should keep his eye on the "taking-off" and lose no opportunity of qualifying himself for it, spending an evening or two every week in studying building construction at classes such as are held at the various polytechnics or under the Education Department, South Kensington. It has been said that in order to take-off properly a surveyor must understand every process in every trade. This is perhaps a slight, but only a slight, exaggeration. The student will do well, therefore, to keep his eyes open and observe any building work, however trivial, that may be going on, if it is only a carpenter putting in a sash-line or a plumber bending a pipe or wiping a joint. Every opportunity, too, should be seized of going over buildings in progress, especially while the workmen are there. True, much information may (and must) be got from books, but the student should make a point of *getting into contact with the work itself*, and should not be satisfied until he has seen an example of whatever he has read of in his studies. Failing this, he will find himself at an immediate disadvantage when he comes into contact with other surveyors, and especially with builders.

General Rules of Measurement. In the following pages it is assumed that the student has become familiar with building terms.

In measuring a length, always measure from left to right. In measuring a "super"—for example, a door—the first dimension taken should be the width, the second the height, and the item would be booked thus:

3 0		2″ deal moulded both sides,
7 0		four-panel door.

In measuring a "cube"—for instance, a stone—the first dimension taken is the length, the second the distance from front to back, and the third the height. This order should never be departed from. Walls, plastering, slating, etc., are measured as if the openings in them did not exist. These will be deducted later. In booking the dimensions care should be taken to avoid crowding. Not infrequently it is necessary to go back and insert a dimension, and a good rule is to leave room between every two dimensions for another. In writing the descriptions it is important to keep well clear of the line on the left, bearing in mind that the squaring has still to come. If any dimension is arrived at by calculation the process should be shown on the right-hand side of the column, thus:

		N 84 0
		E 43 0
		127 0
		Ddt. 10 6
		116 6
116 6		1½ B in cement. *North and East*
14 0		*walls ground floor to first.*

Generally state at the end of the description the situation of the work in question in the building. Read carefully through the specification before beginning to take off. Never put down an item that you do not yourself understand, or do not see how it is going to work, even if you can quote chapter and verse for it from the specification. The architect is entitled to expect you to consult him upon it. Settle your order of taking off, and having settled it, be exceedingly chary of departing from it even if another way seems less cumbrous in a particular case. It is often important to be able to go back, perhaps a year or two later, and follow a measurement without hesitation.

Order of Taking-off. Until some forty years ago it was the practice to take off each trade separately, but that custom is now quite out of date, and modern surveyors, broadly speaking,

measure not a *trade*, but a *thing*, whether it happens to involve one trade only, or several. The exceptions to this rule are joinery, plastering and painting. The following order of taking-off is recommended:

Excavation and concrete foundations; brickwork; damp-proof course; external facings; internal facings; formation of internal openings and recesses; fires; ventilation; external openings; floors; stone or concrete staircases; quarter partitions; roofs; eaves gutters and rain-water pipes; internal plumbing and water supply; drains; hot-water engineering; gasfitting; bellhanging; joinery; plastering and paperhanging; painting.

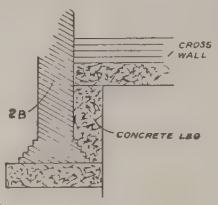
Excavation, Concrete and Walls. If the architect has not supplied a plan of the foundations it is often worth the surveyor's while to make one himself.

The first item of digging is sometimes a superficial one for removing the vegetable soil to a stated depth, say 10 in., but the general excavation is taken by the foot cube. If the contour of the site is irregular, an average depth may be got by a series of ordinates. When the "surface excavation"—to bring the level down to that of the concrete under the ground floor—has been taken, the excavation for the basement is measured, first to a depth of 6 ft., describing it as not exceeding 6 ft. deep, thence to a depth of 12 ft. (or less, as the case may be), describing it as "commencing at 6 ft. deep and not exceeding 12′ 0″ deep," and so on. The description must be worded so as to provide for any old foundations, roots of trees, drain-pipes, etc., that may be encountered. The excavation for the trenches should next be taken, first those below the basement, described as "Excavation for trenches commencing at basement level and not exceeding 6′ 0″ below same," and so on. Now, as to dealing with the earth excavated. In the case of, say, a mansion in a park, where the surplus earth can be easily disposed of, it will probably be sufficient to say of the excavation from the trenches "part returned filled in and rammed, the remainder wheeled, spread and levelled as directed." But usually, and in particular in large towns, where the removal of the earth often costs more than the digging, the portion carted away should be kept separate from that returned and filled in. A convenient way of doing this is first to measure all the earth taken from the trenches as returned and rammed, and then to take items of "deduct return and ram, and add cart away," thus:

150 0	Excavate trenches not exceeding 6′ 0″ deep, and throw out,
3 3	and
5 6	Return and ram around foundations.
150 0	Concrete as described,
3 3	and
2 0	Deduct return and ram,
	and
	Add fill and cart away.
150 0	Deduct return and ram,
1 11	and
9	Add cart away. *For footings.*
150 0	Ditto Ditto
1 2	And
2 9	Ditto *For wall.*

The area of the sides of the basement and of the trenches may now be measured for strutting and planking, keeping them separate. Next take the concrete foundations, using the dimensions of the trenches for this purpose, and not forgetting the "leg" required when a shallow trench abuts on a deep one [see sketch].

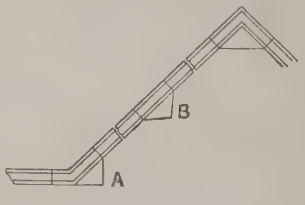
Next come the external walls, beginning with the footings, then the internal walls, chimney breasts and stacks, and piers. Great care is necessary to avoid missing any of the internal walls. A good plan is to take first all that run from left to right, and then all that go at right angles to these. The dimensions of the concrete for the external walls may sometimes be used for the brickwork. The walls may be conveniently taken floor by floor, but chimney breasts and stacks should be taken one by one, from bottom to top. The damp-proof course should next be taken from the measurements of the brickwork—as, for instance, all the one-brick walls collected and the total booked as a dimension by 9 in., and so on. Then the vertical asphalting on the outside of the basement walls next the earth as a "super" dimension, not forgetting to give the total length of the internal angles as "solid fillet at internal angle."



Any requisite steel girders, etc., to support walls on the upper floors should be taken with the brickwork, or noted to be taken later. The chimney breasts usually grow wider as they go up, and require 3 in. or 4 in. self-faced York stone corbels where they set off. Keep separate any brickwork in cement, also any brickwork hoisted more than 40 ft. above the ground-floor level, giving the stages 40 ft. to 60 ft., 60 ft. to 80 ft., and so on. All right angles are included in the price of the brickwork, but a lineal measurement is taken of all others—"birdsmouth," if internal angles; "squint quoin" if external.

External Facings—Chimneys. Measure the weathering on the tops of the chimney caps (super), next the cornices and neckings, etc., beginning with the projecting brickwork (super), and following with the cornice (lineal), as thus: "24.0 Extra on ordinary brickwork for red-brick moulded cornice, as sketch, five courses high, two square and oversailing, and three moulded." Number the mitres and returned ends, and measure the cement weathering on top. Take the general facing down to the roof line.

Copings. Take the brick copings (run), and describe as in the specification, separating the level from the raking and numbering the mitres, etc. Similarly, measure the stone coping, describing the material and the labour—for instance, 64 ft. run, 12 in. by 4 in. Rubbed Portland stone coping, weathered, moulded, and twice throated (as sketch), and set and pointed in cement; 20 ft. run, 12 in. by 4 in.; ditto raking to gables.



No. 4 external angles.

No. 2 internal angles.

No. 3 fair ends with returned and mitred moulding, etc.

No. 2 kneelers (as sketch A), 13 in. by 12 in. by 10 in. (labour and material).

No. 2 bonders (as sketch B), 10 in. by 12 in. by 10 in. (labour and material).

No. 1 apex stone, 16½ in. by 12 in. by 11 in. (labour and material).

Number the cramps as specified. Take fair raking cutting (run) to facings on both sides of the wall under the raking coping.

Cornices. The brick cornices, string courses, and so on will be measured as already described for the cornices of chimney stacks. If of stone, take them by the foot run, numbering the mitres, etc.—for example,

150 0		18 in. by 12 in. Portland stone cornice, rubbed, weathered, and moulded (as sketch), and set and joggle-jointed in cement.
No. 2		Stopped ends.
No. 6		External angles.
No. 2		Irregular angles.
No. 4		Internal angles.

General Facings. The general facings may now be taken, *between* the string courses, etc., but *over* all openings—*e.g.*,

N. elevation	44	6
E. elevation	30	0
S. elevation	20	0
At break 2/.9 =	1	6
	10	0
	14	6
W. elevation	30	0
	150	6

150 0		Extra on ordinary brickwork
28 6		for facings of best red Farehams, the joints raked out and afterwards neatly pointed with a weathered joint.

If the facings be of stone we should, instead, get an item such as the following:

150 6		Rubbed Portland stone ashlar,
28 6		average 6¾ in. on bed and setting and pointing as described.

Internal Facings. Measure the surfaces of the walls faced with brick; also the limewhiting or distempering, taking the description from the specification. In the case of glazed brick facing, give the run of the internal angles as "Extra for waste at internal angles."

Internal Openings. Begin on the lowest floor, and take the formation of all doorways, borrowed lights, archways, and recesses. Example of doorway:

3 0		1 B. deduct
7 0		*Between kitchen and passage.*
3 9		1 B. deduct
6		*For lintel.*
3 9		9-in. by 6-in. concrete lintel, including 2 in. by 2 in. by ¼ in. R.S.T. the whole length; also any requisite casing (brickwork deducted).
2/ No. 6		Extra on brickwork for concrete fixing bricks, 9 in. by 4½ in. by 3 in.
3 9		3-in. tooled York threshold,
9		edges jointed, and bedding in cement.
No. 2		Ends ditto, cut and pinned in cement.

Some surveyors here follow with the joiner's work for the opening.

If, instead of a lintel, we have an arch, we get:

3 2		Centring to segmental arch.
9		
No. 1		Extra labour and waste and cement for segmental arch in cement, 3 ft. span, 1 B. on soffit, 1 B. high.

Fires. Example of measurement of a fireplace.

3 0		
3 0		1½ B. deduct.
No. 1		Extra to segmental arch 3 ft. span, 1 B. × 1 B. a.b. (a.b. means "as before").
5 0		2¼ in. × ⅜ in. wrought-iron chimney bar, caulked and cambered and building in by bricklayer.
3 0		
1 2		2½-in. York tooled hearth, edges jointed, and bedding in mortar.
4 6		*Back.*
1 6		2½-in. ditto, rubbed ditto.
		Front.
4 6		Half-brick in cement trimmer
1 8		arch, and levelling in fine concrete for hearth, and centring trimmer arches.
4 6		Skewback cutting.
4 6		4½-in. by 2½-in. deal feather-edged springer.
No. 1		Filleting soffit of trimmer arch for lathing to.
No. 1		Slow-combustion stove, p.c. £3, and add setting same with the requisite bricks in mortar, firebricks, and fireclay.
No. 1		Rendering in lime and hair mortar to backs of fireplaces.
No. 1		Flue 30 ft. long, parged with cow-dung parge, and cored out at completion.
No. 1		Red terra-cotta chimney-pot, 2 ft. 6 in. high, and setting and flaunching in cement.
No. 1		Chimney-piece, p.c. £4, and add fixing in best manner with the necessary galvanised iron cramps, dowels, and cement, etc.
No. 2		Notching 2½-in. York hearth for jambs of chimney-piece.
4 0		
3 6		Deduct render float and set walls, and Deduct paper at 3s. per piece.
No. 1		Making good in Parian cement to plastering around chimney-piece.

The void in the case of flues (up to 14 in. by 14 in.) is not deducted. It is left to pay for the forming of the flue.

Ventilation. Take, first, all the foul-air extracts, and then the fresh-air inlets. Number the gratings, etc., and fixing, taking the descriptions from the specification.

No. 1. 14 in. by 9 in. cast iron galvanised air grating of approved pattern and building in, including forming opening in 1½ B wall, finished all round with ¾ in. Portland cement trowelled smooth, also the requisite 3 in. tooled York lintel.

The ventilators in the roof are usually taken with the roof.

External Openings. First deduct the brickwork, then take the work on the inside and afterwards that on the outside of the wall.

Example:

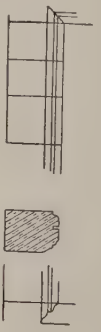
2/	4 6 6 3	1 B deduct.
		Night nursery windows (2).
2/	3 9 6 0	½ B deduct
2/	5 3 9	1 B deduct *For lintel.*
2/	5 3	9 in. by 9 in. concrete lintel, etc., a. b.
2/ 2/	No 4	Concrete fixing bricks a. b. 2/4 6 = 9 0 2/6 3 = 12 6 21 6
2/	No. 1	Window frame 21 ft. 6 in., around bedded in lime and hair and pointed in cement, the sill bedded in white lead.
2/	3 11	Centring to 4½ in. segmental soffit.
2/	3 11 4½	Extra on brickwork for red rubbed and gauged arch in T.L.B., rubbers set in cement and raked out and pointed to match the general facings.
2/	4 2	Ditto, and deduct red facings a. b.
2/ 2/	9	Skewback cutting to facings (at ends of arch).
2/	4 4	Circular cutting to facings (over arch).
2/	4 2	11 in. by 6 in. rubbed Portland stone window - sill, sunk, weathered moulded, throated, and grooved for iron tongue, and setting in cement (as sketch in next column).
2/	No. 2	Fair ends with moulding returned and mitred and stoppings to weathering, etc.
2/	No. 2	Ends of sill cut and pinned to facings.
2/	No. 1	Sill bedded hollow and made up and pointed at completion.
2/ 2/	4½ 6 0	Red facings as before. *Reveals* 6 0 6 6 6
2/	3 9 6 6	Deduct facings as before.

Some surveyors here follow with the joiners' work, etc., of the window.

The external openings should be taken floor by floor, beginning at the bottom and sometimes front by front.

Measurement of Stonework. In the foregoing instance the facings are assumed to be of brick. When, however, the facings of the front or the dressings of the openings are of stone, the measurement of the work on the outside is modified accordingly. It may be convenient at this point, therefore, to deal with the mode of measuring stonework, of which some general account may here be given, though the matter is too complicated to be explained with completeness. All stones not more than 3 in. thick are measured "super." Copings, cornices, string courses, plinth courses, are commonly taken by the foot run, with a sketch of the section, the mitres, etc., being numbered. Sometimes the stones are "cubed up" and described, being classified under several heads, as "cube Portland stone and all labours in plain string courses"; "Do. in moulded do. and cornices"; "Do. in moulded and rebated jambs of doors and windows," etc., accompanied by sketches illustrating the character of the work.

The most scientific mode, however, is to take the stone and the labours upon it separately. The only labour included in the price per foot cube is that needed to saw or draft it to its size, and to hoist and set it. First the size is taken as the smallest imaginary rectangular cube that would contain the finished stone, and if any particular stone is longer than is usual (generally 6 ft. and over), it is kept separate and called "scantling." The heading of the mason's bill should state that "the stone is measured net as set, including preliminary labours." The following are recognised labours taken by the foot super. "Back," the labour on the back of the stone, where it comes into contact with other material—as brickwork; "bed," the labour on the horizontal surfaces above and below coming in contact with stone or other material; "joint," that on the similar vertical faces at right angles to the front face (these are usually added together, the quantity halved, and described as "one face measured for two"); "sunk bed and joint," similar labour to bed and joint, but not rectangular with the adjacent faces, or rebated—as the joints of the voussoir of an arch or the sinking for a door frame (the last-named labour is sometimes kept separate); "circular bed and joint," the labour when convex as at the top of a voussoir; "circular sunk bed and joint," that where concave, as at the bottom of a voussoir when not exposed; "plain work," the labour on the exposed plain surface; "sunk work," that similar to sunk joint, but exposed, as the weathering on the top of a sill. Where the sinking cannot be worked without impediment (or worked "through"), as in a rebate on the outside of a window head, it is



termed "sunk work stopped." This applies also to other labours. "Circular work" is the face labour to convex surfaces—as to the shafts of columns; "circular sunk work," the like to concave surfaces, as to the soffits of arch stones; "circular circular work," the labour to the face when circular both ways, as to the outside of a dome; "sunk work circular circular," that to the inside of a dome; "moulded work" is measured over the whole surface as by a fine string; "moulded work circular continuous," as to the moulded base of a column. The following are taken by the foot run: chamfers up to 3 in. wide, mouldings up to 6 in. girth, groove, throat (*i.e.*, hollow groove), joggle, and the like; stopped ends, mitres, mortises, perforations, and so on, are numbered. Examples:

2/	1 2		Cube Portland stone and hoisting and setting as described. (*Six stones.*) *Jambs of window, south of library.* [See sketch.]
	10		
	5 2		
2/6/	1 2		Bed (one face measured for two).
	10		
		1 2	
2/	2 0	10	Half joint.
	5 2		
		2 0	
2/	1 4	10	Plain work
	5 2	6	
		1 4	
2/	1 5		
	5 2		Moulded work.
2/	5 2		Moulding 4in. girth.
2/	5 2		Groove for iron casement.

Reinforced Concrete. Before we proceed to deal in detail with floors, partitions, roofs, and other parts of a building, we may consider for a moment a new factor in modern building which the quantity surveyor will have to watch very closely. We refer to the use of reinforced concrete, of which the modern practice has been treated in the pages in the course on BUILDING. This class of work is still in its infancy, and considerable developments may be expected, which may result in modifying the mode of measurement in the following paragraph. However, we have set out what is generally accepted at the present time (1915) as the correct method of calculation.

Begin in each case with a description of the piece of work (*e.g.*, pillar, beam, or floor) about to be measured. Then take the net measurement in the same manner as for other work, and express the result as regards concrete in cubic feet, casing (or "false work," or "form work") in superficial feet, and steel in pounds. The measurement of the casing represents only the surface actually touching the concrete. The steel-work should be divided into classes (*e.g.*, bars, stirrups, meshwork, and hooping), the smaller bars (say, under ½ in. diameter) being kept separate, as also those over 30 ft. long. The work in each storey should be kept by itself, and the height stated. Further, each kind of work, as floors, roofs, beams, etc., should be set out in the bill of quantities separately, with the concrete, steel, and casing involved in its construction. The usual method of collecting the work under the head of trades is not followed in this case.

Floors. First take the "hard" floors, then the timber floors. Begin with the basement. Take any requisite hard core (super), describing the thickness, "well rammed and levelled for pavings," the concrete bed, the cement flooring, and the tile or other pavings, to the last-named of which, if the plan be irregular, take a "run" of "raking cutting and waste." To the upper floors take any cast-iron or steel columns or stanchions, girders and steel joists. Cast-iron columns are measured up in detail (super) as metal of such and such thickness, weighed out, 5 per cent. being added for featherings, and billed as:

Cwt. qrs. lb.	
128 2 14	In No. 6 cast-iron columns and hoisting and fixing by bricklayer at first-floor level.
	No. 1 pattern to cast-iron column 9½ in. mean diameter, 13 ft. high, 1½ in. metal, with moulded and bracketed cap and base and moulded necking.

Cast-iron stanchions are taken similarly. Steel joists are taken by the foot run, and weighted out, those over 16 in. deep being kept separate. Compound girders are measured up in detail, and kept separate, with description. This is also the case with riveted plate girders. In the last-mentioned case a percentage is usually added for rivet heads (from 2 per cent. to 5 per cent.). The shanks of the rivets take the place of the holes in the metal.

Connections of girders should be numbered and described. The steel-work of a floor having been taken, next measure the flat-boarded centering, the concrete—giving the thickness—the cement floating, etc., as before described. The timber floors now follow, beginning with the sleeper walls, etc., and the sleepers, plates, and ground joists (cubed up and described as "fir and labour in sleepers and ground joists"). To the upper floors, take any steel girders, and then similarly measure the joists as "fir framed in floors." Take the ends built in, and any stone or iron corbels next flues. Take the herring-bone strutting by the foot run. Measure any sound boarding and pugging over the whole area of the floors, and add to the description "joists measured in."

Slab Partitions. Measure these net as fixed, and describe the method of fixing. Where of irregular shape, take cutting and waste by the foot run. Take pinning up to under side of floors similarly. Enumerate and describe forming door and other openings.

Quarter Partitions. Take each piece of timber by the foot cube, and describe as "fir framed in quarter partitions." Keep separate any that are "trussed," and describe the latter as "fir framed in trussed partitions." Measure the horizontal timbers first, then the vertical, then the raking. Measure the straps by the foot run, and describe as "wrought iron in straps, forged as required, including perforations and fixing by carpenter." Number the bolts.

Staircases. Here follow the stone or concrete stairs, the steps being taken by the foot run by 14 in. by 7 in., or whatever may be the extreme size, and the material, finish, and form—as whether square or spandril—stated. The labour to the ends is numbered as "fair ends," or "fair ends with moulding returned and mitred." The ends cut and pinned are also numbered. Winders are numbered and described, the extreme dimensions being given, with sketches. Next take the landings by the foot super; similarly, the labour on the edges by the foot run, as also the "edge cut and pinned to brickwork."

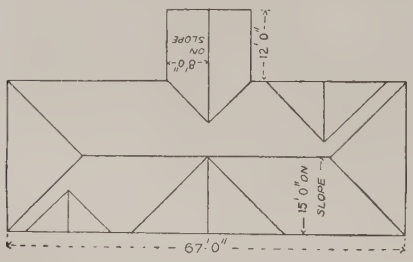
Number the newels and balusters, and the mortises and lead for them. Take also here the handrails, whether of metal or of wood, by the foot run, stating if "ramped" (curved in a vertical plane), "circular level" (curved on the horizontal plane), or "wreathed" (curved in two planes, as at the turn round a well hole). If the handrail be of wood, take at each joint a "heading joint and wrought-iron handrail screw, the heads, etc., let in and pelleted"—that is, concealed with wood pellets let in.

Roofs. If the architect does not supply a roof plan, it is worth while to make one yourself, or get one made. First, take the roof trusses, measuring by the foot cube each timber separately, thus: tie-beam, principals, king-post, struts; and describing as "fir-framed in roof trusses." Number the cleats for purlins, also the cast-iron shoes and heads, giving the weights and stating how many patterns will be required. Take the straps and bolts as already directed for partitions, and number the wedges and cotters, giving the weight. Take also the stone templates and heels of roof truss cut and pinned.

If the trusses be of steel, each piece should be measured in detail, and the whole reduced to weight. The item would then appear in the bill somewhat as follows:

Cwt.	qrs.	lb.	
244	1	7	In No. 7 steel riveted **roof trusses**, 59 ft. span, 15 ft. rise, of 4 in. × 4 in. angle as principals, $1\frac{1}{4}$ in. and $2\frac{1}{8}$ in. diameter tie rods, $2\frac{1}{2}$ in. × $\frac{1}{2}$ in., $3\frac{1}{2}$ in. × $\frac{1}{2}$ in., and 1 in. diameter bar as struts, etc., $\frac{5}{8}$ in. connecting plates, and all fitting, forgings, and cutting, rivets and bolts and holes, and hoisting and fixing by bricklayer, the apex 54 ft. above ground-floor level.

Measure the superficial area of the slating (or tiling) with the deal battens for same, and roof boarding and felt. If all the slopes are of the same pitch, the hips and valleys do not affect the area.



The area of this roof is taken in two dimensions, thus:

2/	67	0	Slating as described,
	15	0	and
2/	12	0	2 in. × $\frac{3}{4}$ in. deal battens
	8	0	spaced for countess slating and well nailed;
			and
			$\frac{3}{4}$ in. deal roof boarding, English cut, closely jointed, and all splays, notchings, etc., and well nailing,
			and
			felt as described, well nailed with clouts, and including laps (measured net, as seen).

Collect the total length of the eaves thus:

			2/	25	6 = 51 0
					27 0
			2/	12	0 = 24 0
					2 6
					3 6
					20 6
135	3		Extra labour and materials to slating at eaves		3 6
					3 3
					135 3

From the length of the eaves may now be taken the eaves fillet at eaves (run), or eaves board (super.), and the plate may be calculated; the roof plate (cube) next, and other horizontal timbers should be taken, as purlins, ridge-rafters, and slate or other ridges with a run of labour to top edge of slating; then the rafters and the ceiling joists (cube), the extra labour and material to slate verge (run), and the deal tilter thereto, the deal tilter and a run of square abutment on slating next gable walls, etc., and the lead soakers and flashings to make watertight connection between the edge of the slate roof and the wall. Lead soakers (super and weighted) are of 4 lb. lead, one to each course of slates (or tiles), lying 4 in. under same, and going 4 in. up the walls; the length should equal the gauge of the slating, plus the lap, plus 1 in.

Number them for fixing by the slater. For secret gutters, about 13 in. of 5-lb. lead is required. Next, 5-lb. lead stepped flashings, 6 in. wide, as cover (super and weighted). Lastly, the running length for lead wedging and for raking out joints of brickwork and pointing in cement to stepped flashings. All lead work is measured strictly net, with no allowance whatever for waste.

To chimney stacks take the deduction of rafters and the addition of the trimmers, etc., also the deduction of the slating, etc. Measure the square abutment of slating down the slopes and the lead work, etc., as to gables; at bottom a 5 lb. lead apron, 12 in. wide, and a run of top edge of slating. At top a lead gutter 8 in. wide. Assuming that the stack is three bricks thick, etc., the gutter is measured thus;

2 3		
8		$1\frac{1}{4}$ in. deal gutter boards and framed bearers.
No. 1		Short length of 2 in. deal rounded roll (across the gutter in the middle).
No. 2		Small 1 in. deal gussets, prepared one side for lead, and fitted and fixed at ends of gutters.
		ft. in.
		2 3
		Extra for roll 8
		At each end 2/.9 = 1 6
		4 5
		ft. in.
		Flat of gutter 8
		Against brickwork 6
		Up slope 1 0
		2 2
4 5		
2 2		6-lb. lead and labour laying in gutters.

No. 2			Ends of roll bossed 2 3 2/.6 = 1 0 3 3
3 3 6			5 lb. lead and labour laying as flashings.
3 3			Lead wedging to flashings, and Rake out and point flashings.
2 3			Large feather-edged eaves fillet, and Extra to slate eaves a.b.

Next, take the hips and valleys, first the timbers (cube), then the length by 6 in. of roof boarding for cuttings, also the length for the slate hips and for cutting and waste on slating. Number the labours at the ends of the hips and the hip hooks at the foot. For a lead valley, super up the 1¼ in. valley board, "splayed and fitted," run the tilter on each side, and super up the lead, the length plus 6 in. at each end, and 6 in. for each lap, by (say) 1 ft. 6 in. wide.

Take the gutters next parapets, etc., in the manner already described, but measure the rolls and drips by the foot run, and at each 2 in. drip, allow 8 in. extra of lead. Take the cesspools thus:

No. 1			1¼ in. deal dovetailed cesspool, 10 in. × 10 in., and 5 in. deep (all in clear), holed, fitted, and rebated for cover.

Super up the lead lining, and number the "extra labour, etc., dressing and copper nailing lead in cesspool," the copper cover, the lead socket pipe to carry the water to the rain-water head outside, and the hole through the wall. All the cube timber in the foregoing is described as "fir-framed in roofs." Another way is first to measure all the timbers, boarding, etc., as above, and afterwards the slating and lead work. Note particularly that the lead work of a gutter should always be carried up the slope of the roof to a vertical height of 6 in. above the sole of the gutter.

Eaves Gutters, and Rain-water Pipes. These are taken by the foot run, now generally measured net, excepting to small breaks, and around pilasters, etc. (which are numbered), the size and description and mode of fixing being given, as thus:

98 0 5 in. by 4 in. cast iron moulded eaves gutter (No. 20 in So and So's list), with rebated joints made up in red lead and two bolts to each joint, and strongly screwing to deal fascia and bedding and pointing in cement on brick cornice, including all cuttings and waste (measured net). The stopped ends, angles, outlets, and covers for same are numbered. In the case of rain-water pipes the swan-neck bends should be numbered, the girth given, and the number of patterns required stated.

Internal Plumbing and Water Supply. It is convenient to include in the heading of this bill a table of the weights per yard run of the lead pipes, the pipes being classified as "waste," "service," and "main." The size of a pipe is the diameter of its bore. The price per foot run fixed includes running joints, wall-hooks or tacks, also bends, unless the pipe is 2 in. or over, in which case the bends must be numbered in addition. Number the soldered ends, also the "branch" joints, stating the size of the pipe—as in the following example:

No. 2			Extra soldered joints to 1 in. lead pipe, or,
No. 2			Soldered joints of ¾ in. and 1 in. lead pipes.

The joints to taps and unions are included with them. Lengths of pipe under 2ft. 6 in. are numbered, the number of bends in each being stated.

Fittings and Wastes. Begin with the w.c. on the top floor. Number the apparatus, giving description and including fixing and all unions and joints. Next take the soil pipe down to the drain and connect thereto, also up, as ventilator, and finish with cap, and take the hole through the wall. Take the water-waste preventer, the overflow pipe from it, and the hole through the wall, the flushing pipe and connection to pan. Similarly, take all other w.c.'s, urinals, etc., discharging into this soil pipe. Take the anti-syphonage pipes. Sinks, urinals, lavatories, and baths and their wastes are measured similarly. Care should be used to take the traps if they are not included in the description of the fittings—for instance, to the lavatories. With the fittings it is convenient to measure any draining-boards, cupboards, etc., connected therewith.

Cisterns and Pipes. Cisterns are usually of galvanised wrought iron. Describe the capacity—*e.g.*, 300 gallons—the thickness of the metal, and the height to which hoisted. If the situation will not allow of a stock size being used, give the exact dimensions. Take any fir or steel bearers, the lead or zinc safe under and waste pipe from same, and the deal cover. Next, take the "warning pipe." If this passes through the roof, take a slater's number item of "perforation" through slated roof for pipe passing through, and making good, and plumber's item for a set of 5-lb. lead flashings soldered on. With each pipe that leaves the cistern take the connection thereto—as:

No. 1			Perforation in galvanised iron cistern for 1½-in. union.
No. 1			1½-in. brass boiler-screw union and fly nuts and 7-lb. lead washers to iron cistern, and soldered joint to lead pipe.

From the cistern take the service pipes to the various fittings (except, perhaps, the sinks, which are now usually supplied from the "rising main"). Measure the chief pipe from the cistern on to the point where it ends, and number the soldered end or tap which finishes it. If, in its course, the pipe diminishes—say, from 1½ in. to 1¼ in.—take at that point a "1½ in. extra soldered joint." Next take the stopcock on it near the cistern; then the first pipe that branches from it to its end, with all its taps and branches, complete. That branch being exhausted, pass down the main pipe till you come to the next branch; exhaust that in like manner, and so on. Having completed the pipes from the cistern (termed "services"), take the "supply pipe"—that is, the pipe from the main in the road up to the cistern—and the ballcock at the end of it. Then the stopcock near the beginning, and next, any branches to sinks, etc. If there are two or more cisterns, take one and all the pipes from it before touching the other. If iron pipes are used, the mode of measurement is much the same as in the case of lead. With the pipes take all pipe-casings (run), also holes through walls and chases.

The hot-water supply, gasfitter, bellhanger, lifts, speaking-tubes, and electric lighting follow here, and are usually dealt with by provisional sums of money.

Drains. Stoneware drains are usually measured to multiples of 2 ft.; thus a measurement of 46 ft. 10 in. is booked as 48 ft. Cast-iron drains are measured net or to 1 ft. lengths. The rule followed should be stated. Begin with the gully at the point of the drain farthest from the outfall, number and describe it, with the excavation and concrete and setting, and take the stone cover. Next take the drain therefrom to the first chamber, describing the size of the pipe, how jointed, and the average depth of the trench and any concrete under or around it. Count up all bends, junctions, etc. Complete the drains that go into this pipe and this chamber, and then take the chamber. Next take the pipe from this chamber into the next, and all branches, with their gulleys, etc., and so on. Finally the pipe from the last chamber up to the sewer in road and connection therewith. Take any ventilating pipes.

Joiner's Work. Measure the floor-boards (super), describing the material, thickness, etc. If any edge of a floor is not square with the others, take the length by 3 in. for waste. With the skirtings, chair rails, dados, and wall-linings, take the grounds, separating those that are plugged or fixed with wall-hooks across flues. Number the mitres, etc., in skirtings, and chair rails, and to dados, etc., take them by the foot run.

Staircases. First take the newels (run), numbering the caps and pendants; next the wall-strings and outer-strings (run), separating the "ramped" and "wreathed," etc. [see page 5738], then the steps, for which take the length from left to right *plus* 1″ at each end (housing). This dimension, multiplied by the width of the tread and the height of the riser added together is the measurement of a step, and should be booked thus:

Tread 11
Riser 6
1 5

3 3 1 5		1¼ in. deal treads with moulded nosing and 1 in. risers, tongued together, glued, blocked and bracketed on and including two strong fir carriages and prepared for cut strings—(if the ends are visible, or for close strings if otherwise). Note that if *a* is the width of the tread and *b* the height of the riser, *a* plus 2*b* should usually equal 23 in.

Winders are measured net, thus:

3 3 3 3 10 9 7		Ditto in winders and risers measured net 6 — 3 3 1 — 3 9 7 — 3 9 — 10 9

If the bottom step is longer and with a semicircular end measure it the extreme length and take in addition an item:

No. 1		Extra on treads and risers as before for semicircular end with solid block and veneered front to riser without heading joint (say) 4 ft. 6 in. girth.

Take housing or returned and mitred ends of the steps; the handrail [see page 5738], number and describe the balusters, stating how fixed at ends, and measure the lathing and plastering to the soffits. Super up and describe the landings, including bearers.

Windows. Measure sashes and cased frames, the extreme width by the extreme height, and give the description from the specification. If the head is (say) segmental, add the words "with segmental head, measured square." The price per foot for this work includes the usual splayed edge on the bottom rail and the splayed edges of the meeting rails. Any further labours are extra and must be taken by the foot run. Mention in the description if weighted for plate glass, also if in two or more lights, with cased mullions. Take the run of the galvanised iron tongue and groove in sill and number the sash fasteners and other ironmongery. Take the glass, bearing in mind that parts of inches are counted as full inches; thus, 11¼ in. is 1 ft. If the glass is of irregular shape, measure the extreme size and describe as "cut to shapes." Take the linings, whether of wood or cement (super if over 4 in. wide), arch traves and grounds (run) the window board (super) and the deduction of plastering and paper. Casements and solid frames are taken similarly but in detail, the casements being supered and described as "fixed," "hung at side," or as the case may be, and each piece composing the frame taken by the foot run and the labours on it described.

Doors are measured by the foot super, the width by the height, and described as:

3 0 7 0		2 in. deal four panel moulded both sides door.

"Moulded and square" means moulded one side and square the other. If a door is glazed, describe it as (say) "rebated and moulded on solid, and prepared for glass," take the run of the small beads as stop for glass (including mitres) and measure the glass.

Next take the linings (super) or the solid frames (run) and the hinges, locks and other ironmongery and architraves. Deduct the plastering and paper. In the case of swing doors measure the run of the rounded edges similarly. Space does not permit of entering into the measurement of screens and cupboards and other fittings, but the student will find little difficulty in adapting the information given above to joiner's work of this kind.

Plastering. Measure the ceilings (super), taking the description from the specification, and mentioning if panelled or coved. Take any ceiling mouldings (run), giving the girth and numbering all mitres, etc. Next the cornices, super if 12 in. girth or over, if not, by the foot run, giving the girth. Number all mitres, etc., giving the average girth of the moulding to which they belong. Bear in mind the "core" for the cornices. The smaller cornices may be in solid plaster, but for the larger ones some "bringing-out" is required, oversailed courses of brickwork, if practicable, and, failing these, deal framed bracketing (super) of about two-thirds the girth of the cornice. Wall surfaces are taken super, the same dimension serving for the plastering and for the papering.

Painting. Painting is usually measured for the most part from the sheets of dimensions after the abstracting and checking have been done. This system has the advantage of giving the surveyor a final look through his dimensions, often invaluable. Measurements in painting are taken (super) "wherever the brush goes," and are classified according to the number of coats, kind of finish, whether in two or more tints, etc. Any work that will have to be done off ladders should be given separately. The measurement of executed work follows the lines of the "taking off" from drawings.

F. H. A. HARDCASTLE

Advertising is True Economy for Buyer and Seller. The Psychology of Advertising. Planning a Campaign. Newspaper Advertising.

THE PRINCIPLES OF ADVERTISING

THERE is nothing essentially modern in advertising. As Mr. Herbert N. Casson has well said, it is like electricity. "It has always been in the world, but nobody knew of it or tried to organise it until a very few years ago. Considered as a profession, it is new; but considered as a force, it is as old as the human race." And certainly for men with imagination and initiative and industry—the three must be combined—advertising does provide a lucrative and exceedingly absorbing profession.

The Most Economical Method of Selling. The definitions of advertising are legion, from the bald statement of the dictionary that it is "the art or practice of bringing one's business into public notice," to the lengthy disquisitions of some of the so-called consultants glorifying it into a science almost as exact as mathematics. We are not concerned here, however, with mere definitions, but rather with facts; and there is undoubted truth in the statement that advertising is the most economical method of selling goods that has yet been devised. This may seem a hard saying to those who have always thought of the advertising department of a business as the great spending, or even spendthrift, department, but its truth may be illustrated in this way.

A merchant or manufacturer producing a household or personal commodity, such, for example, as boots or shoes, takes a page in the "Daily Mirror," or some other large newspaper of proved value, at a cost ranging from £150 to £300, according to the particular page selected. Of the million or more readers who see the announcement, several tens of thousands reply, and eight or ten thousand eventually become purchasers, mostly through the post.

But the sales do not stop with the ten thousand referred to. The majority of these purchasers, being satisfied with their purchases, buy again, and may become regular customers without the need of further advertising expenditure for them. Now, as the purchasers are living all over the country, and the business is done by post, it is absolutely necessary for the firm to go to the prospective customers. They will not pass the merchant's shop and be attracted by his window display. To take ten thousand orders from all parts of the country would require a great number of travellers and an enormous expenditure compared with that involved in the page advertisement. A little consideration and thought will show that in no other way could the goods be sold so economically as by the advertising.

Examples of Advertising that Pays. This is only one of many illustrations that might be given; and the statement about advertising being the cheapest method of selling goods yet devised is proved to be true by the fact that it is adopted by all firms worthy of the name. More than this, practically everybody now advertises. A man is presented by his wife with a son, and so proud is he of the fact that he desires all his friends to know it. How does he set to work? Does he write a letter round to each? No; he advertises in the newspapers, and saves himself endless time and trouble.

A lady loses a gold bracelet presented to her by her husband. Does she walk about the streets day after day, asking every person she meets if he has seen her missing jewel? No; she has a bill printed and stuck up in the shop windows of the district, asking that the finder will bring her bracelet to a certain address, and if it has not been wilfully stolen she will probably get it back. She simply follows the method of an Egyptian advertiser of three thousand years ago, who, when his slave ran away, had a "Lost, Stolen, or Strayed" announcement, made out on papyrus, exhibited in prominent places. We know this, because the papyrus is now to be seen in the British Museum.

The biggest and best army that has ever been recruited on the voluntary principle—one so great that the possibility of success would have been regarded as ridiculous before it was actually accomplished—was recruited, as we know, by means of a great advertising campaign.

Why Advertising is True Economy. Advertising is true economy. Right at the outset it must be fully understood that advertising is not simply an expense. It is true economy, not merely for the seller of goods, but for the buyer. Were it not for advertising, we could never buy soap, cycles, jam, cigarettes, cocoa, books, boot polish, salt, mustard, and a thousand other things of everyday necessity as cheaply as we do now. We have already seen the economy to the seller. Put briefly, the economy to the buyer comes somewhat in this way: a factory has a plant put down to turn out, say, cycles. A certain sum is required weekly to keep the factory going, this sum being wages plus establishment charges—rent, light, power, administration, and so on. (We are not now considering raw material.) By judicious advertising of the right kind, twice the number of cycles now being turned out can be sold.

The advertising is carried out, the increased demand is created, orders come in, and double the number is sold. But in order to make twice the number of cycles the plant does not have to be doubled, nor even do we need twice the number of workers, and certainly the premises do not require doubling, even if they require slight enlargement. The establishment charges being increased so little comparatively, and spread over 2000 cycles instead of over 1000, are naturally greatly reduced per cycle. To a less extent this is true of the wages; and as a result a less price can be charged to the buyer, and yet prove more remunerative to the seller than the higher price per cycle charged when half the number was being produced. This is just a very crude and brief outline of the principle upon which advertising works, and it shows that the idea of the ignorant—that because a firm spends thousands a year on its advertising, therefore the consumer must pay more for his goods—is a fallacy, reasonable though it seems on first consideration.

The Varied Nature of Advertising. So varied are the forms of advertising, and so wide its ramifications, that to give anything like an exhaustive account of all its activities would occupy quite a library of volumes. To mention only a few of the recognised media of advertising which are used by up-to-date and live firms: there are newspapers, daily and weekly, monthly magazines and annuals; show-cards, price-lists and catalogues, descriptive booklets, tramcars, omnibuses, railway stations, and tube trains, electric signs, cinematograph screens and films, theatre and concert programmes, exhibitions, handbills, calendars, lantern slides and lectures, tram tickets, stamp books, novelties, fancy costumes for balls, shop demonstrations, window displays, picture postcards, samples, and so on. With such a multiplicity of media, it is obvious that, before any advertising can be done, something in the nature of a plan of campaign must be thought out, even if it is not dignified with that name.

The Psychology of Advertising. But if we are going to choose our scheme and our channels of advertising well and scientifically—that is, if we are going to get the best value out of the money we spend—then we must know something, at any rate, about the psychology of advertising. Not much can be said here on the subject, although a few points may be given, but the whole matter has been gone into exhaustively by an American professor, who has arrived at some very interesting conclusions. As may be supposed, the power of an object to force itself on the attention of a person depends very largely on the absence of other objects which might act as counter-attractions. The professor, after elaborate experiments, found that the result of doubling the number of figures in a paper exposed to view for a moment or two was to reduce by 50 per cent. the chances of any single figure being particularly noticed. By increasing the figures on the paper threefold, the chances of any one figure being seen was reduced to 33⅓ per cent. The application to advertising of the knowledge thus gained by experiment needs no emphasis here. It is obvious, and will save the publicity manager from many a pitfall.

Attracting Attention. It was also found that the power of an object to attract attention depended upon the intensity of the sensation aroused. Hence the value of good display. Contrast also largely assists in attracting and holding attention, and this applies not only to an announcement set in bolder and heavier type than the other advertisements round it, but also to one set in lighter type than the heavy displays all round. It is therefore often better to go one lighter than one's competitors rather than to attempt to annihilate contiguous advertisements by weight and massiveness and excess of colour. Repetition, too, has been proved a most valuable principle in fixing an object, a name, or an idea upon the mind. Hence the need for continuous advertising. Spasmodic effort never secures the valuable assistance that the principle of repetition does.

Other Principles Involved. Other principles that have by experiment as well as by practical experience been proved of the utmost value in securing attention may be briefly referred to. The value of an appeal to the feelings is great; hence the suggestion of the bright and the pleasant, in both illustration and matter, should always be attempted. Suggestion plays a large part in human life, and it is of the utmost usefulness to the advertiser. But the keen advertiser will not be satisfied with mere suggestion; he will remember that the great bulk of human-kind dislike thinking for themselves, and prefer to be told what to do rather than to make up their own minds as to what they should do. The direct command, therefore, "Get a jar today," "Tell your grocer you must have Blank's," "Write for a box at once," and so on, will often clinch the matter, when a mere general request or a suggestion would result in no business at all.

Advertising Appropriation. Advertising is too serious and too important an item of expenditure to be done in a haphazard fashion. The advertiser should always have some definite idea as to what he intends to spend during the ensuing twelve months. The sum set apart is known as the advertising appropriation, and some firms decide on the amount of their appropriation not only for the twelve months but for the two or three years immediately ensuing. This enables the publicity campaign to be properly organised and planned out, and the relation of one year's scheme to be intimately connected with another's. The actual amount set aside is, of course, a matter for each firm to decide for itself, but a word or two may here be said as to considerations that must be taken into account.

The advertising should be reckoned as a part of the selling cost, and should therefore be roughly estimated as a percentage on the amount of probable sales. But if the turnover has gone down, another consideration comes into account: Should the amount spent in advertising be more or less in the succeeding year? Some firms have been in the habit of making it less, on the principle of cutting down expenses; others have increased it after a bad year, on the principle that more advertising is needed to bring in more business. The latter is the plan that is now most favoured by up-to-date experts in business.

In reckoning the cost of advertising, however, we must have some idea as to what is to be charged up to this account. Here, again, there is a great difference of practice in firms. Some put down everything that can by any stretch of the imagination be remotely regarded as advertising the firm or its goods, as, for example, stationery. Not only do they charge up the printing on the notepaper and envelopes, but also the paper itself. Even invoice and statement forms and labels are, by some, regarded as legitimate advertising expenditure; and there are firms that place the expenses of travellers—salaries, commission, fares, hotel expenses, and samples for carrying—to the advertising account. If any distinction is made between the advertising and the sales departments, then obviously these should go down to selling and not to advertising. It would be almost as reasonable for a grocer to regard the assistant behind the counter as an advertising charge as for the manufacturer to do the same in regard to a traveller.

The scientific method, coming more and more into vogue, is to charge to the advertising department only such schemes and plans as are for publicity independent of the actual selling of goods. Thus in a scheme by which tradesmen were induced to stock largely a particular soap, by giving them an extra discount of 1¼ per cent., the amount of discount involved would go down as a selling charge pure and simple; but if with it was connected up a plan for getting window displays by

giving them a pound's worth of goods for the display, the latter would be charged to the advertising department. The sales and advertising departments, however, are so interdependent, and have necessarily to work in such close touch with one another, that it is not always easy to decide to which the cost of any particular scheme is to be debited. The matter must be decided carefully by every firm for itself.

Planning the Campaign. It is in planning out just what form an advertising campaign is to take that the most important part of the work comes in. Shall the publicity be obtained entirely through the newspapers? And if so, shall dailies or weeklies or both be used? Shall the great national papers, published in London, alone be used, or shall the provincial journals also be brought into service. And if so, are these to be the mornings or the evenings of the big towns and cities, or the local weeklies of the smaller towns and districts? Or shall posters on the hoardings be selected for the campaign, or enamel plates at the railway stations, or a house-to-house distribution of samples and literature? Or shall there be a combination of some or all of these methods, with others not enumerated?

Then again, shall the campaign be a general one, reaching all over the country, or shall it be confined to the big centres where the people congregate—London, Liverpool, Birmingham, Newcastle, and so on? Or shall a certain area be selected, town and country, as for instance, the Eastern Counties or the Midlands, or Yorkshire and Lancashire?

These questions must all be thoroughly thrashed out before any money is spent; and unless expert knowledge is available in the firm itself, it is always wise to consult specialists for advice, such as the big advertising agencies. It is certainly wise, however, for every large firm to have an experienced advertising manager and control its own policy in detail, while using the agencies as space-brokers and designers.

Choosing the Media. The media must be very carefully chosen. No one would, of course, be so foolish as to advertise a whisky in a Nonconformist religious weekly, nor malted milk in a racing journal. The most general and extensive advertising of ladies' blouses would hardly embrace the ironmongery papers or the "Journal of Chemical Science." But while such incongruous instances of useless advertising would not be perpetrated by the most ignorant advertiser, yet there are many cases scarcely less incongruous to be found every week, though they do not always appear so ridiculous to the lay mind.

Every class in the community has its special organs or its favourite journals; and when a prospective advertiser has decided to whom he means to appeal, expert advice is needed as to the channels through which these people are most effectually to be reached. It is expert knowledge, therefore, that is essential to decide upon the relative values of newspapers, magazines, circular letters, railway plates, hoardings, etc., for any particular purpose. Only with such knowledge can a wastage of money be avoided.

Specialist Treatment Needed. Every coat, of course, has to be cut according to the cloth; and whereas for a big campaign a combination of, say, newspaper advertising, billposting, sampling, and other methods may be used to give the maximum of results, in a smaller scheme it may be better to concentrate on one particular channel, as, for example, the newspaper. In any case, the trade must be notified as to what you are doing, either through the usual trade organs or direct by post and through your travellers. Propositions vary so, and different kinds of goods need such different kinds of treatment, that it is impossible here to give any stock plan of campaign. The advertiser must, first of all, think out clearly in his own mind what he actually wants to do, and then decide upon the best way of doing it, after weighing the pros and cons of a variety of means. So many advertisers make a bad beginning by never having any really clear idea in their own minds of what they want to do.

Various Publications. Of the newspaper as an advertising medium something is said below. Newspapers take a large and ever-increasing part in the work of publicity, but they are not alone among publications. The monthly magazine is also a valuable medium, and it has this advantage over the newspaper—that its life is not so ephemeral; it lies about for a month at least, and its advertisements have currency, therefore, during that time. Here, of course, as in all other forms of advertising, the right organs must be selected for the particular class of people it is wished to reach. Thus for first-class children's boots, a high-class jam, and so on, a publication like "My Magazine" would be selected, as circulating among exactly the class of people who would be likely to buy a high-class article or commodity.

Quality and Quantity of Circulation. Circulation is, of course, a very important matter to be considered. All other things being equal, it is much more valuable to insert an advertisement in a paper with a circulation of one million than in one whose circulation is only half that number. And in arriving at a decision, when comparing alternate media, it is important to know whether circulation figures presented stand for copies printed, copies sent out, or copies actually sold, exclusive of all returns, free copies, vouchers, etc. But even when all this is decided, quantity of circulation is not everything. Quality must be taken into consideration also, and to many advertisers quality is more important than quantity. For the advertising of a cheap margarine by a multiple-shop concern, a publication that had an enormous circulation—say, a million—among the poorer working classes would be valuable. But it would be worth nothing as compared with, say, "My Magazine" referred to above, if the article advertised was a high-class garment at a good price, although the circulation of the one would naturally be less than that of the other.

Classes of Journals. But the general newspapers and magazines appealing to all classes and conditions of people do not exhaust the valuable media open to advertisers. There are what are known as the class journals, those that appeal to certain sections of the community, such as religious papers, the women's journals, Nature and outdoor publications, literary journals, etc. All these are extremely valuable for certain purposes, and should never be ignored. We may put it stronger, and say that, wherever possible, sections of them should be included. For many articles it is by means of the class journals that the advertiser can most effectively and most economically reach his public.

Large Spaces versus Small. The size of the spaces to be taken in the newspapers and magazines depends largely upon the amount of

money that can be spent over a given period. It also depends upon what exactly the advertiser is desirous of doing. If, for instance, he has about £250 or £300 to spend, and ten thousand ladies' umbrellas to sell, it might be well to take the front page of a big London paper, or perhaps even two pages, thereby spending all the money at once. By such an effort it would be quite possible and probable to clear the whole stock of articles, and achieve the purpose desired.

On the other hand, if the advertiser's aim is to keep a steady and increasing trade going, with some article of general use as a household commodity, then he does not want to make one big effort like a flash in the pan, with nothing succeeding it. In such a case he would take smaller spaces, letting his announcements appear perhaps once or twice a week, and occupy eighths or sixteenths of the pages. Even smaller spaces, such as two or three inches, are extremely valuable if run as series, provided the article advertised is some well-known popular commodity that needs little or no description, such as Chivers' Jellies, Mellin's Food, etc. In this case the idea is general publicity, by keeping the name constantly before the public, so that they shall not forget it, and so that a rival article shall have less chance of supplanting it in the public mind.

Advertisements should, as far as possible, appear next to matter, even if a higher rate has to be paid. Right-hand pages are better than left, and the tops of pages or columns are better than other parts, unless in the lower place a solus position is secured —that is, a space entirely surrounded by matter, or having reading matter at the top and on either side, or on one side if the advertisement is in an outside column. Such positions on right-hand pages are the most valuable of all. The reason right-hand pages and columns are better than left is that the eye naturally falls to the right rather than to the left, owing to the fact that we are right-handed and right-brained.

A small and striking advertisement appearing again and again is in most cases better than a large announcement published occasionally, on a principle that "a constant dropping wears away stone," and a constant hammering eventually does its work. The cumulative effect of regular and constant advertising cannot be over-estimated. As far as possible a regular advertisement should occupy the same space and position in different issues, in order to assist this cumulative effect.

Type, Border, and Pictures. It is in the selection of type, borders, and pictures that the expert has his opportunity. Many striking and artistic types are now available in the printing establishment of every high-class paper and magazine. Excellent borders, too, may be had for the asking, and the advertising man who knows his business will soon be able to know what types and borders are best suited to his purpose. It is a mistake to change too often the particular kind of type used for a firm's name, or the title of a branded article, as in doing so the continuity is broken. Some of the most successful advertising of recent years is that which has retained a particular type or border with very slight modifications. Whatever change is made there should always be something similar about a new advertisement to that which it displaces, in order that the continuity may be preserved.

Illustration plays a large and growing part in effective advertising. The picture should always be simple, without an excess of detail to distract the eye; it should be well drawn, and it should tell the story. The irrelevant picture is of little or no value; in fact, it often leaves an impression on the mind that prevents the right impression from remaining.

Mr. Herbert N. Casson describes advertisements with such pictures as "April Fool Advertisements." "The distinguishing mark of this species," he says, "is a headline or illustration that has no connection with the subject. Its aim is to trick people into taking notice of it. Apparently there is nothing in the goods to interest the public, so the advertiser throws in a picture of the Eiffel Tower, or an ostrich—anything that happens to be handy—to brighten up his advertisement. The result is an advertisement that may be very catchy and attractive, but that is almost quite worthless as a seller of goods. It does not create a strong impression. It does not convince. It divides the reader's mind, and the part that is interesting is not the part that is of any value. Worse still, it gives a shock to the mind. It shows you a fine picture of the Eiffel Tower, and then, when your attention is secured, it says 'April fool! I only want to tell you about the Smith brand of shoelaces.'"

Badly drawn pictures cheapen an advertisement —together with the article advertised. They should never be used. Of course, in small spaces there is often not room for a picture, but wherever possible a really relevant picture does help in arresting the attention in the first place, and leaving an impression on the mind after the paper containing the announcement is laid aside. Care must be taken to supply a newspaper or other journal with such blocks as it can print well. Half-tone blocks with a fine screen are useless for newspapers printed on a rough, inferior paper. In all cases of doubt it is much better to be on the safe side, and supply good line-blocks.

Black versus White. Then comes in the question of the relative value of black on white and white on black. Many advertisers think that they can secure more than a fair share of the attention of readers by making their announcements heavy, with a predominance of black. This is usually done by having a panel of black with the announcement upon it in white lettering. The effect is dazzling; it is far from pleasing, and it is doubtful if, all things considered, it really has any more lasting impression on the mind of the reader than black on white. Certainly the effect in the pages of the newspaper is so ugly that all the leading newspapers are now declining to receive or print such blocks.

Copy. Of course, when speaking of the importance of selecting good pictures, types, borders, etc., it is assumed that the copy or matter is effective. It is the most foolish economy to buy expensive space in newspapers and magazines, and then to fill it with anything but the very best of matter. Copy must be written by one who is an expert in the business, whether it be long or short. And here arises the question as to whether short, snappy advertisements, with a few lines that can be taken in at a glance, or reasoned arguments, running to four or five hundred words and more, are most effectual in attracting business. Both styles have their advocates, and for both there is much to be said.

The truth probably is that both styles are good. For some articles and commodities the short copy is, in a general way, best, while for others the long copy pulls most. Patent medicines are an instance in which long copy seems to be extremely successful. People will read an almost unlimited amount

of matter consisting of testimonials and descriptions of cures effected, or said to be effected, by pills, ointments, embrocations, and so on. On the other hand, for household commodities like jams, jellies, cocoas, etc., a few lines would seem to be more useful. But in neither case can any hard and fast lines be laid down. It is good from time to time to tell the story of the jam or jelly or cocoa at extended length; and where the story of the ointment or whatever it may be is being told at length fairly frequently, it is very useful to give reminders of the name between the appearance of the larger advertisements.

Style Needed. Whether the copy be long or short, it must have style and individuality. If it be short, then the sentences which give in a few words the points about the article must be pithy, slightly epigrammatic, though not so brilliantly clever as to be over the head of the ordinary crowd; and the language must be simple enough to be plain to the dullest understanding in a moment. People will not in these days stop to think over advertisements of this type, and so the phraseology must be very plain, and the words Saxon as far as possible. Thus, "begin" is better than "commence," "end" than "conclude," "see" than "observe," and so on. There should also be a rhythm in these sentences, harsh combinations of words being avoided. In this way the memory of the reader is assisted to retain what he sees.

As to the larger copy, as much care should be exercised in preparing this as in the production of an article. The language should be good, nervous English, but above all it should be absolutely clear. The reader should never have to read a sentence twice, or even to dwell on it, in order to grip its meaning. Long sentences should be shunned, but, on the other hand, the sentences should not all be so short and snappy as to give a fragmentary, broken, and disconnected feeling when being read.

If the story of a product or its use or composition or history is being told, then the story should be consecutive. Point should lead up to point, so that, after reading the advertisement through, a person shall have in his mind a clear idea of the matter by means of which he is unconsciously compelled to conjure up a mental picture. It is the mental picture that will live in the memory and recur. Thus, if the story of a food product is being told, the reader should find rising in his mind a scene in which fresh air, hygienic surroundings, a perfectly clean factory, and healthy, rosy workers, with spotlessly white overalls, all combine to form a pleasing picture. This picture will then recur whenever the commodity in question is mentioned or appears to the eye.

The Expert Advertising Man. Obviously, literary skill is required for this, hence the need for experts as copy-writers. Mere commercial knowledge is not sufficient for an advertising man; he has to have such knowledge, but in addition he must be something of a salesman, an artist, an editor, and an author. Mere tricks of composition, such as alliteration and elaborate metaphors, should in a general way be avoided, but, as already mentioned, there must be rhythm and what has been described as "the music of syllables." Exaggeration, a redundancy of adjectives, superlatives, attacks on rivals, should all be avoided. They belittle the advertiser and shake confidence in his bona fides.

It has been said that a good advertisement is as rare as a good editorial or a good novel. "If Edwin Markham worked fifteen years to write 'The Man With the Hoe,' it is not to be expected that a famous 'ad.' can be written in fifteen minutes," says an expert. This is true; and although the public who read and remember good advertisements never dream that any particular pains or time have been expended in their preparation, it is safe to say that all advertisements worthy of the description "good" have in their composition a vast amount of "sweat and blood." The famous advertising phrases, "Worth a guinea a box," "I hear they want more," "Made in the country, away from the dirt and the dust of the town," are not, as a rule, brilliant inspirations, but well-beaten-out gold, modelled and remodelled many times before they reached their present form.

Topical Advertisements. There is a great advantage to be gained by giving a topical touch to advertisements. Very often a person who would never trouble to read an ordinary advertisement will be arrested by some topical allusion, and will be induced to read on until he has assimilated the strong meat of the announcement to which the topical reference was but the relish. Many excellent instances of topical advertising have appeared in the newspapers and magazines during the Great War. Some old-fashioned firms are too dignified to descend, as they describe it, to topicality, but, as has been pointed out before, dignity has ruined more men than drink. Of course, it goes without saying that anything in the nature of vulgarity must be strictly avoided.

Definiteness Needed. There is one thing that cannot be over-emphasised: an advertisement should always be definite and specific. There is something wrong about the wording of an announcement for shirts that could be transplanted bodily to an advertisement for gold-clubs, or a gramophone advertisement that would equally well fit an Axminster carpet. Then about every article or commodity that is being well patronised by the public there must be some one selling point at least which leads people to buy it in preference to similar goods turned out by other manufacturers. What is that one point? Or if there are two, what are they? It is the advertising man's business to find these out, and clearly and concisely to state them in his announcements.

Hard Work Essential. Advertising is by no means an easy business. It is one of the most difficult of professions. As Mr. Herbert N. Casson has said: "The publicity man has a bigger job than the salesman. Why? Because the salesman handles men one at a time, while the publicity man handles the whole public at once. The man who writes the 'ad.' can't make a joke on the other fellow, because the other fellow may read it. He can't whisper of special favours. He has to work out in the open, where everybody can see him. If he makes a mistake, he can't forget it, like a salesman; or blame it on induction, like an electrical engineer; or deny it, like a public official; or bury it, like a doctor; or charge twice for it, like a plumber. He has to face it, and own up. The publicity man stands between his company and the public. He must understand both. He must interpret each to the other. If he does not know his company, he has nothing to say; or if he does not know the public, he does not know how to say it. A real, thoroughbred publicity man knows the public as the pilot knows the sea. He knows the rocks and the currents and deep places. He makes it his

business to keep in touch with all sorts of people. . . . The real publicity man works over his 'ads' as an architect works over his designs."

The Test of Distinctiveness. Many an advertiser, looking at his announcement appearing regularly in the papers, thinks that it stands out from all the other advertisements. And to him it undoubtedly does. Even if he is glancing through a paper with no thought of his advertisement in his mind, his eye instinctively goes to the announcement as he turns to the page on which it is. But this is no real test of distinctiveness. The man can pick out his own house in a street containing a hundred villas, all alike. To him the house is unique, but to strangers it is just one of a hundred. And so it is with an advertisement. If a man wants to know whether it is really distinctive and stands out so as to attract notice, he should take the opinion of other people.

If an advertisement is to be in two or more colours, as when it appears on the cover of a magazine, it is worth while to remember that red is the colour that stands out best. Green is also a very distinctive colour.

Getting the Help of the Salesmen. It is always wise for the advertising manager to keep in close touch with the salesmen. They can give him many hints and points that perhaps he himself has no knowledge of. They know all the possible arguments against the goods they sell, for they are hearing them every week from the shopkeeper, and some of these are sometimes worth meeting beforehand indirectly in the advertisements that are appearing regularly in the papers. On the other hand, the advertising manager must exercise his discretion. If he is going to carry out every suggestion received from his firm's salesmen, he will spend a great deal of money and make a rare hotch-potch of the advertising. The wheat must be sifted carefully from the chaff; and although the chaff may predominate, there is always a certain proportion of wheat well worth having.

Trade Paper Advertising. So far, general advertising has been dealt with, but in most businesses, particularly manufacturing, a certain amount of advertising in the trade organs has to be done regularly. The character of this is, of course, quite different from the advertising to the public. In the latter the idea is to give reasons why an article or product should be used, but in the trade paper we have to tell why the shopkeeper should stock our goods. Here such phrases might be used as "Good profits, quick returns," "The beverage that is advertised all the year round," "A large margin of profit," and so on. Blocks of the article or the package may very well be used.

The articles which follow describe principally various phases of newspaper advertising, all of which are of great importance, and must be thoroughly understood by the advertising man.

CHARLES RAY

ADVERTISING AGENCIES

BY WAREHAM SMITH

Advertising is obtained either through an advertising agency or direct from the advertiser, and the agents handle about 90 per cent. of the business appearing in newspapers.

It will be seen from this that the advertising agencies play a very important part in the business, and their position in the field is rather a peculiar one, for the reason that although they work ostensibly in the interests of the advertiser, they receive their remuneration from the newspaper. On all contracts placed by the agency the newspaper pays a commission, varying from 10 per cent. to 15 per cent., according to the standing of the publication and its power to command business. Various other arrangements are often entered into, such as an additional discount for cash, or an extra commission if the business received exceeds a certain amount. The agency is responsible to the newspaper for payment for contracts placed by it, and is regarded as a principal, all contracts being made as such, and not as an agent of the advertiser.

How the Agent Works. It is not, perhaps, of great importance for present purposes to inquire into the inner working of an advertising agency, but it is at least relevant to the subject, and digression in this direction may not be uninteresting. The agency acts: (1) as space-broker—that is, buyer of space from the newspaper on behalf of the advertiser; (2) as advertisement manager and adviser to the advertiser.

In either case the commission paid by the newspaper is the same. Some agency businesses consist entirely of the former class of work, some the latter. Others combine the two according to the requirements of individual clients. Generally one of two methods is adopted by the advertiser in prosecuting his campaign:

(1) He organises an advertisement department under the control of a man who combines a knowledge of advertising with the study of the exigencies of the advertiser's particular line of business, or (2) he places himself almost (in some cases *quite*) unreservedly in the hands of an agency. In the former case he makes such arrangements as will, in his opinion, ensure that his business will be properly and profitably conducted.

His advertisement manager is generally a man with an extensive knowledge of the art of advertising. He has learnt from experience what to buy in the way of space, and the lowest rates at which it may be obtained. He designs copy, or has in his department experienced copy-writers, and, being on the spot, he has his fingers on the pulse of the business, and should be able to tell without loss of time when a publication or a particular advertisement fails to show a profit on the outlay. Almost invariably he employs an agency to act as space-broker, to make the necessary arrangements with the newspaper. By doing this he often saves time and money, the agency, acting for several advertisers, being frequently able to buy more cheaply.

Importance of Agency Work. Turning to the second method, the properly equipped agency can—and generally does—render very important service to the advertiser, whether his outlay be large or small. It may act as an advertisement manager, and, in addition, bring to bear the experience gained by years of experimenting and observation made in the interests of numerous clients with diverse interests. The agency maps out the campaign, the publications to be used, advises as to buying space, and secures best positions possible. It writes the advertisement copy and booklets; executes illustrations, and makes the process blocks; designs posters and sees that they are properly displayed; organises, where necessary, a follow-up system; originates selling schemes; checks accounts, to make sure that the advertiser has received the space ordered and charged for.

THE NEWSPAPER AS AN ADVERTISING MEDIUM

By J. Murray Allison

Every advertising medium has its uses and value. For many purposes the daily paper is supreme. In its highest developments, advertising is itself news—news about merchandise, news about the business affairs of the world, news about novel or advantageous commodities of daily life. Such daily-life news is best appreciated when published in a paper which appears daily to print the news. It is also in the daily paper, cheek by jowl with public news, that the announcements of the business man—Government loans, municipal issues, the prospectuses of public companies, and the like—find their proper atmosphere. There are, moreover, certain advertisements for which the daily paper is the only possible, the only natural medium; such are advertisements for servants, announcements of the theatres, concerts, public gatherings, meetings, and, of course, Births, Deaths, and Marriages. These partake more intimately than the other advertisements of the nature of news. Each is an announcement which states a definite, tangible fact, for which the daily paper is the one suitable channel of communication.

Requirements of *daily* life—I mean commodities of household consumption, the needs and luxuries of every household every day—need the daily paper as the bearer of their message to the public. There are needs of less frequent fulfilment which may be advertised in more leisurely publications, the weeklies and monthlies, though the daily paper is unsuitable for hardly any.

The Serious Side of Advertising. For the advertising of serious books and reviews, the daily newspaper is a highly eligible medium, because of the frame of mind in which it is read. The daily paper is itself serious in spirit. It goes with the business man to his office; it is brought back to carry the news of the day to his household. It discusses weighty matters with appropriate gravity. The mind of the same reader is much better attuned to serious advertising when the daily paper is before him than when he reads for amusement the lighter weeklies and magazines. The same reasons which make the daily paper a superb medium for advertisements of important books make it applicable to the advertising of expensive and deliberate purchases. An estate or a house, or anything else that is bought to last a lifetime or for a long period of years, will not be sold by light arguments, or bought in a frivolous frame of mind. Chattels of price—a grand piano, a suite of furniture, a motor-car or equipage, or a cellar of wine are examples—will be best advertised when the reader is seriously disposed: still more an investment will be made then, and not in hours of relaxation.

The daily paper, however, is not closed to advertisers of luxuries and amusements. More especially those which a man buys as presents for his family, or upon which (by reason of their high expense) he is generally consulted, can with enormous advantage be advertised in the daily Press

Economy in the Dailies. The advantages of the daily newspaper do not end, however, with its unique applicability to certain current advertising. The daily paper has a special appeal to the advertiser on the score of price too. It can sell its space at a much cheaper rate per inch per thousand than any other medium, except the great news-weeklies which resemble it in character and outward appearance. One factor of this circumstance is that the news-journal can be printed upon paper very much less costly than that upon which the illustrated weeklies and magazines are published. Another is that the large circulations of papers that are strictly newspapers make them cheaper to print, by spreading the initial cost of editing, news, and typesetting over a large number of single copies. Large circulations also make possible the use of fast, and therefore economical, printing-presses.

Admitting, then, that the newspaper Press offers him special advantages, an advertiser has to determine the value for his own purposes of each individual publication. In order to arrive at an estimate of this value he will ask himself, in respect to each paper, certain questions, such as, What is its circulation? What is the status of its readers? What is their capacity as buyers? Here we reach a very interesting and delicate situation.

The whole relation of circulation to the price for advertisements is an interesting and complicated question for advertisers. Some papers wisely state their circulation, others wisely do not. One class relies on the number, and the other on the quality, of their readers.

Sunday and Provincial Papers. The relation to advertising of the great Sunday weeklies is in many respects identical with that of daily papers. The extension of daily paper circulations has seriously affected the former greatness of the provincial weeklies. Very few families in the kingdom get through life today without a daily paper, and the dailies of large cities like London, Liverpool, Manchester, Leeds, Glasgow, etc., cover vast areas of population formerly reached only by the provincial weekly newspapers. Thus the influence and advertising value of the latter have greatly declined. Many of them are still powerful, and practically all respectable. Their decline from a former paramount position in rural Britain has led to consolidation, the same paper being published in a number of towns, with localised title-headings, a small amount of matter of purely local interest being peculiar to each edition.

Censorship of Advertising. How can the newspaper help the advertiser? One way in which a paper can help the advertiser very materially is by safeguarding the environment of his announcements, keeping its own advertising columns as clean and as reputable as its editorial columns. The policy of the "Times," and, of course, of other high-class journals, is to refuse any advertising which is contrary to good taste, untrustworthy, or fraudulent in intent. The presence of questionable advertisements prejudices the whole of the advertising in a newspaper. Only by the assurance which experience brings that the advertising matter is unimpeachable will readers look with favour upon the business announcements which a paper publishes. An advertisement gains force and value from the prestige of its medium, and advertisers are not slow to appreciate the importance of this.

Control of Display. Another matter in which the paper can help the advertiser is, in my opinion, by limiting the kind of "display" in its advertising pages. I hold the opinion, and I believe it is a sound opinion, that the presence in a page of an unsightly drawing, often accompanied by type unduly large and black, damages every other advertisement and defeats its own object, since the only advantage of large and

black type, and of blatant illustrations, is contrast. Where the same "bad eminence" can be attained by all comers there is no pre-eminence. Advertisers whose "copy" is refused by newspapers on these grounds often at the moment feel aggrieved; but, upon reflection, they are able to see the wisdom of the advertisement manager who will not allow them to enter into a rivalry of this sort.

ADVERTISING FOR RETAILERS

By Richard Burbidge

There are two ways of advertising a retail shop, or —shall I say?—two divisions of retail-shop advertising. One is to utilise the Press; the other is to employ miscellaneous advertising by post—circulars and catalogues being forwarded to old customers and to addresses of those whose custom is sought. In the case of a shop doing a good and progressive business, Press advertising is the most important. By means of the newspapers the retailer can speak to millions of persons every day, and invite just the persons whom he wants to come to his shop. Naturally, much depends upon the advertisement.

As a general principle, it may be said that the right purpose of a retail advertisement in the Press is to bring customers to the shop to buy a specific article. It must be a good article, of course, giving full value for the customer's money. That particular article should prove that the shop is worth patronising in the future. A satisfied customer is a permanent customer.

Importance of Good Copy. It does not seem to be generally recognised that the success or failure of a retail establishment may actually depend upon the wording—commonly called the "copy"—of its advertisements. Advertising is a science which amply repays all the time devoted to its study. The retailer's advertisements should be bright, crisp, simple, and direct in language, and contain prices stated in plain and unmistakable figures. There are experts who declare that an advertisement should contain the announcement of a single article only—an article to bring customers to the shop, where they can see other bargains. That is a good principle, but it is not an infallible one. At sale-time, for example, shop advertisements are miniature catalogues, containing, perhaps, in a couple of columns of a daily paper anywhere from twenty to forty articles. The object at sale-time is to attract all classes with all kinds of goods; therefore the announcement of a single article would, in my opinion, be a mistake.

Of course, any retail advertisement is actually an advertisement of the business as a whole, but a big business is only built up by selling many articles. The first thing to do is to get your shop well known, and that means that the majority of your preliminary advertisements must deal with some specific article on which the retailer relies. He knows that it will attract hundreds or thousands of customers, and all he wants is to get them inside his shop. Therefore a good retail advertisement, although it may contain offers of numerous articles of merchandise, really is advertising the shop after all. That is what it is used for.

Put the prices in the advertisements. Many a good customer is frightened away because she fears that the article specified may be dearer than she thinks it is. No one is going to risk humiliation by suddenly discovering that the price is beyond the purse. As for illustrations, my experience is that a good illustration is always worth the money, and a poor one only so much hard-earned money thrown away. If a paper cannot reproduce blocks well, do not illustrate advertisements in it.

I would like to impress upon retailers the need for versatility in their advertisements. How often do we see the same advertisement appearing day after day, not a word altered or a phrase brightened! The reader's eyes wander mechanically over it without the brain receiving any impression; in fact, it is money wasted.

Advertising by Post. I now turn to the question of advertising by post, with circulars and catalogues. It will be found a good idea to regard this class of advertising as the foundation of your business, leaving Press announcements to build upon the foundation. In other words, the Press advertisement is like the mason's work on a building. Catalogues are apt to be thrown away after a general glance, or they may be merely laid aside and forgotten. The daily or weekly advertisement in the Press revives memories of the catalogue, and therefore each kind of advertisement dovetails with the other, forming a continuous whole.

The Press advertisement brings more inquiries than the catalogue and the circular, but every inquirer should be made a customer, not by newspaper announcements, but by a judicious supply of advertising literature. Send a catalogue or a circular to the right person at the right time, and follow it up by a prominent display in the Press, and the result is always satisfactory.

Catalogue Lists. Every well-organised and progressive shop keeps a carefully compiled list of customers, and notes as to the purchases of each. This list is an index to the character of the persons patronising the shop, and indicates the kind of goods they want. The wise retailer, therefore, keeps his list up to date, and sends catalogues suited to the requirements of each customer. A very important point to bear in mind in sending a catalogue is to enclose it in an envelope of decent quality. The catalogue that arrives in a flimsy envelope is more often than not consigned to the waste-paper basket unread, or even unopened. The more often a catalogue is issued, the better it is for the retailer.

Advertising during Sale-time. Advertising during sale-time is a difficult thing, but, speaking from experience, I should advise the selection of a dozen different bargains to be advertised, confining them to things in general use, such as bedding, dresses, linen for both sexes, and similar articles. Again I say, constantly change the advertisement.

Points Worth Noting. A few remarks of a general nature may be worth making, especially to the retailer in the smaller towns. First of all, do not advertise an article and put the customer off it when she enters the shop. Take one article at a time, and boom it. It must be a first-rate article, of course—one on which the vendor can stake his reputation. That article will serve as an introduction. It will get customers into his shop, and once they are there he need fear nothing.

A big clientèle having been secured by advertising, the retailer should be most careful not to lose it. He must go ahead, and keep going ahead all the time.

In conclusion, advertising is of vital importance to the retailer, and any time and trouble spent on it is always amply repaid. A shop must be kept in the minds as well as the eyes of the public. For the

thousands who can see it there are millions who cannot. To reach them, the Press must be used, but success depends upon the methods adopted.

MAIL-ORDER ADVERTISING

By J. McBain

Mail-order advertising is the publicity employed to sell goods by post, whether it takes the form of advertisements in the daily or periodical Press, circular letters, booklets, folders, or a combination of any or all of these elements. The seller, or advertiser, may be (1) a general mail-order trader catering for a variety of needs, and supplying such things as household linens, blankets, rugs, dress materials, suits, furniture, cutlery, and a thousand other articles either for the home or for personal adornment. Such a trader may have showrooms where local customers can make their purchases, but the bulk of his trade will be handled through the post; (2) a trader in a speciality; (3) a particular department in a retail business formed to supply the requirements of those who cannot conveniently shop over the firm's counters.

The aim of the "general" mail-order man is to secure as big a list of customers as possible, irrespective of any consideration for the profit he may make on the first transaction. Supplying, as he does, a multitudinous variety of articles, he need not, and probably does not, hope to make a profit on his first sale; that is to say, if the prime cost of the article, plus the cost of advertising it, exceeds the amount he receives from the customer, he has not necessarily any cause for dissatisfaction. This customer is now on his books, and, assuming that he has no reason to regret his purchase, will in due course, at small cost, be persuaded to buy other articles; or, if his first purchase be something consumable, such as a box of cigarettes or cigars, he will in all probability repeat the order.

It is obvious, therefore, that a mail-order advertiser of this type makes his profit out of a particular customer, not on the first sale, but on the sum total of the transactions he has with that customer.

To treat a customer generously is a good thing in any business, but perhaps in none is it more desirable and more profitable than in a general mail-order business. It assists in creating that goodwill which is so valuable an asset to the mail-order man, for it saves him, as we have just shown, from one-half to two-thirds of his cost of selling.

With the mail-order department of a large retail business the same general principles apply to the question of profit margin.

Advertising a Speciality. Very different is the position of the advertiser of a speciality, Either he has no other article to sell to a customer. or, if he has, the chances of subsequent sales are too remote to be worth taking into account. It is absolutely essential, therefore, that he should make a profit straight away. This means that the margin of profit must be very much greater than in the cases already discussed

Announcements in the daily or periodical Press represent the chief means employed by mail-order advertisers to sell their commodities. These announcements may attempt either to sell the article to the consumer at once, or they may only attempt to arouse the reader's interest to the point of inquiring for further particulars, which are duly sent to him in the form of booklets, leaflets, folders, circular letters, etc. In the case of more expensive articles, costing from, say, ten shillings upwards, it is usually hopeless to endeavour to effect an immediate sale. The British public thinks twice about remitting any considerable sum of money for an article until ample opportunity has been afforded for considering its merits.

Selling an Expensive Article. A mail-order advertiser, therefore, if desiring to sell a comparatively expensive article, should advertise in the first instance for inquiries, unless he is prepared to offer his goods on approval or guarantee return of money in case of dissatisfaction.

But whether immediate sale or inquiry is the object of the announcement, the form of the advertisement is more or less the same in each case. It used to be an old saying that in an advertisement the less said the better. This is certainly not true of mail-order advertising, in which the rule seems to be rather that one should endeavour to get into the available space all that one can possibly say about the goods and the offer without making the advertisement unattractive and unreadable.

It is a well-known fact that successful mail-order advertisers study with the minutest care all data bearing upon the pulling power of their advertisements, and the discovery of some little point which has hitherto escaped their observation has often led to largely increased results.

While it is impossible to draw up hard and fast rules, it can at least be said that simplicity should be the keynote of all mail-order copy. All attempts at cleverness should be severely repressed, and the advertisement which is content to be a simple, straightforward statement will in nine cases out of ten bring most business.

With regard to the particular media which should be employed by mail-order advertisers, the best results appear to be obtained from London morning papers which enjoy a national as well as a metropolitan circulation. After these come the more important weekly and monthly publications, and after these again the provincial Press. Media whose circulation is confined exclusively to large towns where facilities for purchase over the counter are abundant should be avoided.

Up to this point our remarks have applied equally to advertisements seeking immediate sales and to advertisements seeking inquiries. With regard to the former there is nothing more to be said. With regard to the latter we have to convert inquiries into sales.

Inquiries not Sales. This is a suitable point at which to state with some degree of emphasis that inquiries are not sales. An advertisement may produce one thousand inquiries and yet show a loss, while another advertisement producing only five hundred inquiries may show a handsome profit. The element which determines the value of the advertisement is the ratio of sales to inquiries.

A Typical "Follow-up Scheme." Assuming that the office organisation is all that it should be, what are the conditions with which we have to deal? An advertisement has appeared inviting those who read it to apply for further particulars of a certain article. There has been considerable response, and the office has in its possession the names of a number of people who have taken the trouble to inquire either by using a coupon or by writing a postcard or letter. The advertisement has cost, let us say, £20, and the problem now is to convert into sales a sufficient percentage of these inquiries to recoup the cost of the advertisement, and show, in addition, as large a profit as possible.

It is obvious that if the article has a big margin of profit it will be possible to make more than one

attempt to bring each inquirer's interest to the buying point. A typical "follow-up" scheme, as practised by a mail-order house dealing in specialities, might be as follows: (1) The answer to the inquiry, consisting of a folder or booklet, describing the article and the terms on which it is offered, and a letter stating any salient points in the offer;

(2) A reminder, consisting of a brief letter or even postcard, directing the recipient's attention to the previous communication;

(3) An offer of the article on approval, consisting of a letter explaining the offer, a leaflet or folder recapitulating the matter contained in the original booklet, and a reply postcard, to be used if the recipient wishes to avail himself of the offer.

(4) Another reminder, directing attention to the offer on approval.

With regard to No. 1, the chief item is, of course, the folder or booklet; and a wise advertiser will devote considerable time and thought to its preparation. It should be long enough to enable the advertiser to tell his story fully and clearly, but not so long as to risk wearying the reader.

Good Paper and Print. Speaking generally, it will pay to spend enough to ensure good paper, printing, and get-up. The use of two colours is almost indispensable in a piece of advertising matter which is to stand out of the ruck.

The covering letter should be made as strong as possible. Not a single unnecessary word should be employed. If possible, the letter should be written in the first person, and signed by an individual, thus creating in the mind of the recipient the desirable impression that he is dealing with a definite person and not with shadowy and soulless office machinery. The "second shot" will consist of a letter.

Shot No. 3 marks a new departure. Two previous communications having proved fruitless, it is assumed that the inquirer has lost the greater part of his pristine interest, and that some entirely new proposal is necessary in order to arouse him from his lethargy. What more suitable than an offer to send him the article on approval, carriage paid both ways? Such an offer not only argues confidence in the merits of the article, but a desire to deal frankly with the customer.

The Offer "on Approval." The offer on approval is the great stand-by of many mail-order advertisers, who rely on it to produce much business they would not otherwise get. Of those who take advantage of the offer, 60 per cent. to 80 per cent may reasonably be expected to become actual buyers, always provided that the article is found to be as described. In any event, some new proposal or offer is needed in this third shot.

Shot No. 4, which completes the series of "follow-ups," requires no special comment, except that, being the advertiser's swan-song, the appeal should be as strong as possible. In the case of most propositions it will not be found profitable to make further efforts. Indeed, where the margin of profit is small, Nos. 2 and 4 would have to be dispensed with, and No. 3 made to mark the limit of the advertiser's follow-up system. As to the intervals of time that should elapse between the shots, an average period of ten days is most suitable.

The question of postage is a much-debated one in connection with "follow-up" systems, some favouring penny and others halfpenny postage. From inquiries made by the writers, the general consensus of opinion appears to be that penny postage will bring more results, but that the difference may not compensate for the increased cost.

WINNING CONFIDENCE

By Sir Thomas Dewar

The successful man of today must treat his public honestly as from man to man; in absolutely no other way can he make them his clients. True, public support can sometimes be won by a successful advertising coup, but the buying public are not sentimental; they quickly find out if they are not getting their money's worth; and once a trader loses their confidence, practically nothing can win it back. When a man has anything beyond brains to sell, he soon finds out that morality and money-making have to keep pretty closely hand in hand. No matter how much is spent on an article that is not good value, it will never pay. If you succeed in deceiving the public and they resent it, you will find they have long memories. It is a good deal more expensive to reclaim a lost name than to make a new one.

Beware of Change. To keep the confidence of the public you must not make abrupt changes; the public of every country are very suspicious. I have had good proof of this. For example, some years ago in the Malay States circumstances made it necessary for us to change the whole style of the labels on our bottles. Instantly there was a sharp decrease in the orders, and the amount of the shipments fell considerably. I found on investigation that the fall was solely due to the change in the labels. The well-off Chinamen, who were the chief consumers, although they could not read a word of English, knew the label well, and would not be convinced that the contents of the bottle were the same if the label were different. It took many years to regain their confidence; in fact, we did not succeed until they had become accustomed to the label.

It is a most dangerous test of public confidence in any way to alter a label or trade mark to which they have become accustomed. Even if you have gained two or three extra medals at exhibitions, to add them on to your label or trade mark will raise suspicion. This is a curious but undoubted fact.

To copy another man's form of advertising is never successful, and to copy the methods of a man in your own business is simply to advertise your rival's goods. The public always associate certain methods of advertising with certain names.

Map out a policy for yourself, be sure you are right, and then go right ahead.

To keep the confidence of the public one must keep persistently before them. "The man who on his trade relies, must either bust or advertise" is sober fact for trading men. It is no use to offer a reward for the return of a lost opportunity. Advertise persistently, right from the beginning. Keep at it. Remember that a prophet is no prophet in his own country unless he is an advertising man.

Slow Returns. To get the full benefit of public confidence from advertising, you should not expect any outward return until the end of the third year; but if you don't get any by the end of the fourth you may take it that your money is lost. You are making some mistake, or your article is not all right. There are two certain ways of losing money: first, to advertise and then leave off; second, to advertise a bad article. Unless you can show an increasing turnover in your business you are not holding the public confidence. Something is wrong. Investigate.

Training. Office Work. Estimating from Bills and Drawings. Measuring Up. Extras. Day Work.

IN BUSINESS AS A BUILDER

THE building trade is one of the most important and permanent industries of the country, and is likely to attract into its ranks in the future, as it has done in the past, young men of energy and enterprise. It may be well, therefore, before our subject-matter proper is dealt with, to call the reader's attention to the great changes that have taken place in this trade during the last thirty years, and have most vitally affected it and the prospects of those who intend to enter this business.

Changes in the Building Trade. There is no doubt that for the moment, though it is to be hoped not permanently, the old-fashioned type of builder is on the decrease; the builder who had first-hand practical knowledge of some or all of the trades employed in the erection of buildings, who had gone through a most practical training in the workshops, and who, in proportion to the thoroughness of his training, took pride and interest in his business—this type of builder is being pushed to the wall in the stress of modern competition. His success depended not merely on his ability to undercut his competitors in a tender list of twenty but on a reputation gained for sound, though not always, it must be confessed, cheap building; and it is open to grave doubt whether the building public in the end stands to gain by the gradual disappearance of this type. Into his place is stepping the mere financier, who chooses the building trade as the field of his operations, and whose training has made him a master of office detail, but has left him without any practical knowledge of the various trades connected with his business. Besides the change in the type of builder, there is another tendency to be noted, which is, perhaps, its necessary concomitant—that is, the tendency on the part of furnishing firms and great stores to establish an architectural and building branch of their business, and with the help of the large capital they have at their command, to enter into competition with the genuine contractor; for in these days of rush and hurry it is apparently a tempting consideration to be able to choose your house at the same place as you buy your furniture. It should be noted, however, that the competition of these firms has at present more effect on the decorative side of a builder's business than on the actual contracting, though not without its influence here, too.

Signs of the Times. These changes are undoubtedly signs of the times, and must be taken into consideration by any one proposing to enter business as a builder; but, significant as they are, there are reasons for hoping that they indicate a mere temporary phase, and not a permanent alteration of the conditions under which the building trade has been carried on in this country. Architects, too, it is to be hoped, will be found on the builders' side in this matter; their work is far more likely to be intelligently and efficiently carried out by firms whose interests lie only in the building trade, and whose principals have practical knowledge of building detail, for they will thus secure the great advantage of dealing direct with such builders instead of with the subordinates of great financial houses, as they would have to do if the "trust" methods of business were to prevail in the building trade.

Technical Training. Technical training may be said to be the foundation stone of success for the builder and of most vital importance if he wishes to have a real knowledge of his trade and a living interest in his business, and in these days such training is open to all. The old order, it is true, has changed. The days of apprenticeship, whether for good or ill, are gone for ever, but the intending builder has no lack of efficient substitutes. Thanks to the various technical institutes in London and throughout the country, practical training in all the various building trades lies within his reach at a very slight cost. Many polytechnics have a course of day and evening classes for intending architects and builders, where they can learn both the theory and the practice of their business; and after having been through such a course, the student, though not master of every trade, should be sufficiently acquainted with them to know good construction from bad, and to realise whether the workman in his employ are efficient or the reverse. Perhaps the ideal training for a builder is a course of these technical classes, and at the same time attendance on a building in the course of erection. From the latter he would be able to learn not only how a building is put up from the foundation to the finish, but also to gain some knowledge of the handling of workmen and the general management of a job.

Office Work. With these remarks as to the preliminary training advisable for a builder, our subject naturally falls under two heads—the builder's work in the office and his work outside in supervising and managing his jobs. It is not at all uncommon in building firms where there are two partners for them to divide the duties, one taking entire charge of the estimating work in the office, and the other visiting the contracts in hand, seeing to the ordering of materials as they may be required from day to day, and settling any question that may arise on the work itself. The convenience of this division of labour is quite obvious, but it is not a desirable method to employ. A builder should know all sides of his business, that if need arises—as it is sure to do—he may be capable of dealing with any branch of it. The office work is by far the more important of these two, though the term may be slightly misleading. By it is meant not the mere daily routine of the office, which, with little variation, would be the same in a builder's as in any other, but more specifically preparing estimates and all that has to be done in the attempts to secure contracts. This side of the business presents far greater difficulties to-day than it did twenty years ago. The fight for work and the competition in the building trade becomes fiercer every year; prices are cut to their lowest point, and that not only by those who may be called the "plungers" of the building trade, and in this severe struggle for work scientific pricing of estimates is

often entirely sacrificed, the writer knowing of more than one case where a builder, after making up his estimate, has taken off a good round sum "for luck," as he says. With this increase of competition there must be a corresponding increase in intelligence on the part of the builder if he is to keep his place in the ranks of the successful.

The modern builder must be prepared to face the new conditions, for though some of the severe competition is due to temporary depression, it is in the main due to causes that will probably prove permanent. The public have demanded the cheapness that unlimited competition gives, and architects have been compelled to bow to the popular demand. The builders, too, have themselves to blame in part for this state of things; when tender lists were more select, the work was often too costly, and the inevitable reaction on the part of the building public was bound to come. Under these conditions, the estimating side of a builder's work has become more than ever important and increasingly difficult, and it is no exaggeration to say that it is only after the most assiduous application that skill and certainty in estimating can be obtained.

Invitations to Tender. There are certain kinds of public work that are advertised, and are open to public tender, and there are some builders that almost confine themselves to this kind of work. Speculative work, also, is, of course, open to all builders with capital, or with the ability to borrow capital. But apart from these two classes of contracts, it is difficult, even in these days of competition, for a builder to obtain the opportunity of submitting a tender. Architects, quite naturally, send their work to the men they know, and of whose skill and trustworthiness they have had experience, and unless specially advised, would not include in their lists of "invited to tender" a builder unknown to them; but if recommended to them, architects are not hostile to the young and untried man, and are quite willing to give him the necessary opportunity. For instance, a London architect, with a job outside the London area, would always ask, in addition to his usual list of builders, the local builder to tender, if satisfied of his capacity, because, if for no other reason, he should be able to carry out the work at less cost than his London competitors. The difficulties of obtaining the entrée into the "invited to tender" lists are great, but not impassable, and should not debar any man of capacity from entering business as a builder.

Estimating. A builder may have to estimate for contracts in one of two ways — either from quantities or from drawings, and in the latter case, he will have to take off his own dimensions. In these days quantities are almost always supplied, and it is only in the case of small alteration jobs that a builder should have to take out his own—not many of the principal builders would take out their own in competition for a large contract. It is far easier to estimate from quantities than otherwise; but even then one of the most difficult tasks a builder has to do is to prepare a correct and careful estimate. It is a comparatively simple matter, by low pricing, to secure a contract; but it is much harder to prepare an estimate that will not only secure that, but also show a profit at the end of the job. To all who know anything of the building trade it is common knowledge that there is often a variation of from 20 per cent. to 30 per cent. in the prices of different builders tendering for the same job, and all quantity surveyors can testify how greatly the different prices of different builders vary in detail—some pricing their brickwork low and their joinery high, or vice versâ. This variation can be easily understood if the detailed and many-sided knowledge that is required for accurate pricing is taken into consideration. In the ordinary building there are a dozen or so different trades employed, and the estimating builder must know not only the prices of the various materials needed for these trades delivered to a certain site, but must also have some idea of what the labour on these materials will cost; and it is precisely the latter, or the human element, of which it is so difficult to ascertain the cost.

In passing, it may be remarked that the price book is not to be relied on as a certain guide, although it is very useful for occasional reference. A builder should be able to price the bills of quantities that come to his office from his own first-hand experience; this is not to say that he is never to employ an estimating clerk—most builders do—but it is unwise to depend on him entirely.

Estimating from Quantities. Before beginning to price his bill of quantities, the builder must satisfy himself as to one or two points which might seriously affect the estimate he will be giving. Common-sense will, of course, tell him that building is more expensive in some parts than others—for instance, that in a hilly suburb of London, like Hampstead, it is more costly for him to do work than in the centre of London; all materials would cost more, owing to the heavy cartage, but such knowledge as this he will have from his own general experience. His first business should be to visit the site of the proposed building; he should discover what facilities there will be for the storing of materials—limited space for this purpose will mean increased cost—whether the site is easy of access for carts to draw into, and whether there are any special difficulties connected with it. He should satisfy himself as to the nature of the soil—whether, for instance, it is easy to work or not, and whether sand or ballast can be had from it. Another important point to see to is whether there is likely to be much water met with during the excavations. There is in most bills of quantities a clause to pump or bale out all water met with in the course of the work, and this, in some cases, would amount to a serious item. The estimator having ascertained such points as these on the spot, can return to his estimating with knowledge that will materially help him in his pricing, but before settling down to his work he should call and inspect the drawings, that he may know whether the proposed building is a simple one, or likely to be expensive, because of minute and elaborate detail, the designs of different architects varying considerably in this respect, and appreciably affecting the cost of their work. When beginning the actual pricing of the bills, the builder should have before him the cost of various materials, such as bricks, cement, etc., delivered to the site, and the cost of carting soil and rubbish from the works, this last item varying from 10 per cent. to 15 per cent. in different parts of London. He can sometimes deduct something from the prices thus obtained before tendering, as the merchants are likely to quote him lower prices if he succeeds in obtaining the work.

Fluctuation in Prices. It is the more necessary to obtain such prices, because the cost of some materials varies appreciably—sometimes from month to month. Metals such as lead and iron are very liable to be affected in this way, and if there is a considerable amount of such material in a bill of quantities it is advisable to obtain from the

merchant a price that will be guaranteed for a time sufficient to allow of ordering at that price if the tender should be accepted; otherwise the builder may find himself in serious difficulties. A concrete instance will at once illustrate this. A builder gives in an estimate for a contract in which there are many hundredweights of lead; he comes out lowest in the list of tenders, is accepted for the work, and begins operations about a month after the sending in of his estimate: he will not require his lead either for external or internal work for many months. He has priced this in his estimate at £15 per ton; between the time of sending in his tender and his wanting the lead it has gone up £3 or £4 per ton, and if he has made no contract with his lead merchant at the time of starting his work for lead to be delivered to his works as and when required within twelve months, he stands to lose very heavily on this part of his work. Metals, bricks, cement—the prices of all these are controlled by what are virtually trusts. The builder, therefore, cannot rely on getting lower prices for materials than those he has based his estimate on. The absence of competition makes it certain that the price he will have to pay when he comes to do the work will be the same price he was given by the different merchants when estimating.

Preliminary and Other Items. The preliminary items should be given careful attention in pricing, especially the time given for completing the contract—almost always inserted by surveyors in the bill of quantities—and the time required for maintenance after the building is completed; this varies from three months and upwards and is sometimes as long as twelve months, and can be a very serious item. A case came within the writer's own knowledge where the time for maintenance was eighteen months; the contract was for redraining a large estate, the drains of which had settled owing to the shifting of the ground. The builder was made liable in the contract for damage to the houses on the estate during the time his work was going on, and for eighteen months afterwards for any damage due to the work being carried out; it is obvious that with a treacherous soil this might be a very serious matter for the contractor. Two other items that should be carefully noted are the fees for the district surveyor and local authorities, and for the water required for the works. In the case of alteration to large buildings, should the quantity surveyor not have included a sum for the fees as a provisional amount, the builder would be well advised to write to the district surveyor and ask him what his fees would be. As to water in the London area, the charges are now fixed by Statute, and can be found in any book of reference. The weight of the pipe required for services is the same throughout the London area, but in some cases outside that area the service pipe is required to be heavier even than the London Board's Regulations, and the unwary builder may get caught in this way. In such a case the builder should write for the water company's regulations and requirements.

Specialities and Provisional Amounts. Where bills of quantities contain specialities such as a large amount of granite work or terra-cotta, the estimator should always obtain prices, however experienced he may be; they are quite outside the run of his ordinary knowledge, and it is imprudent to risk making any mistakes—mistakes in estimating are expensive luxuries. However, prices for specialties such as these are often obtained by the architect direct from firms who deal in them, and inserted in the bill of quantities before it is sent to the builder—being known as "provisional" sums. The continued increase in such amounts has been brought about by the great changes in modern building construction and the consequent elaboration in such matters as steel construction, sanitation, and the heating of buildings. The gradual elimination of timber and the substitution of fireproof construction in both floors and roofs has deprived the builder of much of his work, and in some cases reduced him merely to the position of general banker for the contract without any of the usual advantages of that position. For though in the bills of quantities the estimator is always instructed that he must add his profit to such provisional amounts, if he really wants the work he never puts anything on, and all he can be certain of getting out of them is a small cash discount such as 2½ per cent., and this even is not always allowed by the special firms employed.

Closing Remarks on Quantities. The estimator should always carefully read through the headings that precede the bill of every trade; they usually consist of the description and quality of the materials to be used, but there are sometimes items that require pricing and others that call for special attention. There was a bill of quantities within the writer's experience where, included in the headings of the joiner's bill, was a clause that the first instalment on the contract would not be paid until all the doors had been got out and framed together, an item that quite escaped the estimator's notice. If there is any pulling down or any other spot work to be priced this should be done on the site itself; it cannot be properly done in the office. If it is stated that the builder will be allowed to use such of the old materials as are sound and suitable, only a visit to the site and inspection of the existing building and fittings will enable him to tell what credit he should allow under this head. Before finally making up his tender the builder should see the specification and contract. It is true that usually all the items that require pricing are inserted by the surveyor in the bill of quantities, but it is best to make sure. Nowadays, in estimating it is usual to add the profit on each separate item. A better though little used method is to price each item at the prime cost and add a percentage at the end for office expenses, use of machinery, the general superintendence of the job, and for profit. This way is old-fashioned and the modern surveyor is not used to it, but it is to be preferred, for two reasons—it makes pricing more scientific and accurate, and in the case of additions and alterations it certainly tells in the builder's favour to have a definite percentage added on to the whole, especially where there are items for which there is no price in the schedule.

Estimating from Drawings. If estimating where quantities are supplied is difficult, the task is doubly so where there are no quantities and the builder has merely the drawings and the specification to rely on, or in some cases where no drawings are needed, the specification only. Such cases are almost unknown with buildings of any size, and for work exceeding £500 quantities should be taken out.

There are two kinds of work for which it is very usual for a builder to have to estimate without quantities—small alterations and additions to existing buildings, and repairs and decorations. In the case of the first, drawings would be supplied, and from these the builder can get a surveyor to

take off the quantities for him if time should be allowed, though often he has the loan of the drawings only for a day or two; but, in any case, builders of experience would prefer to take off their own quantities, and this is not a difficult matter if the builder has an ordinary working knowledge of drawings and dimensions. He will not do it, of course, with the accuracy and fulness of a surveyor, and his method will be rather rough, but, backed by experience, it will suffice. Without experience, however, the builder had far better go to the small expense of employing a surveyor than blunder along as best he can. Or if this is not feasible, owing to want of time, he had better decline to tender. In the case of repairs and decorations—much the most common—the estimator must take the specification with him to the job in question, and do all pricing there, because a careful examination of the existing work is now considered to be necessary.

Measuring Up. If estimating preliminary to the obtaining of contracts is the most difficult task a builder has before him, a scarcely less difficult one is the measuring up the extras and omissions on the completion of a contract, and settling up the accounts. That no contract is ever completed without extras and omissions is almost a truism. Building operations do not lend themselves to terminological exactitude, and not the most skilful architect or surveyor can foresee all the contingencies that may arise during the course of the work, much less control the changes of mind to which building clients are so liable. The questions arising from these variations in a contract of necessity lead to much discussion between builder and surveyor, and the builder needs tact, judgment, and good temper if he is to deal successfully with them. In addition, there may be also matters arising out of the bills of quantities. The builder may find them deficient in certain particulars, or may think certain items insufficiently described, or the labour to an item not properly taken. In all such matters there is plenty of room for difference of opinion. The builder is naturally anxious to get all that he considers himself legitimately entitled to, and the surveyor is equally concerned to see that the builder does not get more than his rights, though his position is not one of a partisan, but of an umpire—a position from which builders can rely on most quantity surveyors not deviating. Now, in measuring up as in estimating there are two courses open to the builder. He can himself meet the surveyor and go into all the various questions with him, or he can employ another surveyor to act on his behalf. In the case of large contracts there is much to be said for the latter course, or in cases where the builder foresees that acute disputes are inevitable, and that, in consequence, first-class expert advice will be of the utmost help to him; for it may well be that in such circumstances the builder will have neither the time nor the ability adequately to present his own case, and the extra expense of employing a surveyor will be more than justified.

Extras. There are two subjects which are very liable to cause controversy between builders and surveyors—extras, which there is no schedule price to govern, and day work. In the case of the former, when there is any considerable variation—such as, say, the substitution of wainscot for deal in a building, or any large addition to the contract—it is quite usual for the architect to get an estimate from the builder before ordering the work, a preferable method to leaving it to be settled at the end of the contract, and fairer both to the client and the builder. Where the variation is slight, and no estimate is given—and most contracts will show some few items for which there is no schedule price—compromise as to price ought not to be difficult. The usual method is for the surveyor to price out the extra and omission bills, and forward them to the builder for his approval. He may put the prices too low, anticipating that the builder will ask too much; but in most cases the builder will find himself able to accept as fair the prices offered, and will always find the surveyor open to conviction if he can prove that any particular item has been priced below its real value. For it is not the unfairness or partiality of a surveyor that the builder has to be on his guard against, but the ignorance that arises from knowledge gained by theory instead of practice. The writer has in mind one particular instance of this. The taking down of a door, easing, adjusting, and rehanging in the same position was priced by a surveyor at 1s. 3d. The builder would want 3s. for it; the surveyor might say that, theoretically, a carpenter should do the work at this price, but the builder would know from practice that not a carpenter could be found in London to do the work for 1s. 3d.

Day Work. But a more fertile cause of difference of opinion than extras outside the schedule price is the question of day work. There is not much difficulty about the actual prices—for, to most contracts there is a schedule for day work attached—but as to what kind of work a builder is entitled to charge under this head. Where the builder claims day work, the usual custom is for him to send into the architect weekly vouchers of the time and materials. Sometimes the architect will accept these outright, but more usually with the proviso that the surveyor must go into them at the conclusion and decide whether the work in question can be measured or not. Where there is a clerk of the works, he has to sign the weekly sheets; and where this is done, and the architect has accepted them, the builder should not forgo his claim to have this treated as day work; the surveyor has then no right to an opinion on the matter. But when, at the end of the contract, the day-sheets are handed over to the surveyor for adjudication, the builder must satisfy him as to the reasonableness of his claims. Some surveyors, unwilling to admit any limitation in their own profession, are too apt to think that any and every kind of work can be measured. Should the builder have the misfortune to meet such a surveyor, he must decide what he has a right to charge day work, and insist on his rights. A builder's claim to day work may be based either on the nature of the work itself or the conditions under which it is carried out. Under the first head would come such work as the cutting away for hot-water fittings, unless the builder has to take the risk himself.

There is, for example, a provisional amount inserted for hot-water work, and sometimes the general contractor has to do the necessary cutting away for the fitters and to price the item as he thinks best; but more frequently there is a provisional amount also for the cutting away, and the builder returns what he does under this as day work. It is obviously impossible to measure a hole cut in one place and a hole made good in another. Under this head, too, would come alteration to work already done, such as alteration to drainage already laid. Where the day work claim is due to the conditions under which the builder has to work, it is advisable for him, before doing the work, to point out to the architect that he cannot do it at

the ordinary contract rate, always, of course, presuming that there is no clause in the contract to cover work under such conditions. Work of this kind would be, for example, that done to the interior of a school while in occupation of the children, where the builder has to do the work as best he can, and to suit the convenience of the teachers; and where the builder is not required by his contract to work under these conditions, he is quite entitled to charge it day work.

Excess and Deficiency. Before leaving the question of settling accounts, one other matter must be touched upon—the excess or deficiency of quantities. Bills of quantities can either form part of the contract or not. In the latter case the builder's claim, if he thinks there is a deficiency in some particular, would lie against the surveyor who had taken out the bills. Where the quantities form part of the contract, which is the usual course, the surveyor, when measuring up, will not raise the question of excess or deficiency, presuming that the quantities are correct, but will leave it to the contractor to make a claim if he wishes. But the builder will be advised to be very careful before he makes such a claim. Nowadays, quantity surveyors are scientifically accurate, and the contractor, unless he should discover any considerable omission, will not find it worth his while to raise questions on small points which, while involving much labour, will bear little practical fruit. In this matter the builder will do well to restrain the zeal of his foreman. Many foremen, when a job is being measured up, are eager to point out that the quantities are short in this or that particular, without, of course, having gone into the general question whether it is worth while to raise the question of quantities, and a foreman should always be advised to refer such points for the contractor's consideration and decision. One other point the builder must be prepared to meet—the accuracy of his own prices in the bills. This will arise only in the case of extras and omissions. For example, suppose there is an amount of galvanised iron tongue in the bills taken out per foot run, priced by the builder, probably in clerical error, at 1s. 6d. per foot instead of 1½d. On the completion of the job there is found to be a large quantity extra, and the surveyor will wish to price this quantity at the usual price. The builder must here stand firm—the bills of quantities form a schedule that must not be departed from, whether the error is in his favour or not. If it had been against him, the surveyor would have shown no mercy. Of course, in some cases, errors of this kind are detected, when the builder deposits his priced-out copy of the bills with the surveyor, and in that case he is asked to correct the error without, of course, altering the total of the contract sum.

Outside Work. It remains very briefly to consider the work that a builder has to do in supervising and managing the contracts he has in hand. This side of his work, though second in importance, can be by no means lightly regarded. The great quality he will require, whether dealing with the client or the architect or his own workmen, is the quality of tact. Personality tells here more than on the other side of his business, and the possession of tact may make all the difference to the keeping or losing of a connection. The jobs on hand should be visited frequently, so that the builder may see for himself that satisfactory progress is being made, and that if any difficulties arise he may have immediate knowledge of them. One of his most necessary equipments will be a thorough practical knowledge. Questions may arise any day as to the best and safest way of carrying out his work when the knowledge of his foreman will need to be supplemented or corrected by his own. The foreman may be inclined to sacrifice safety to speed, and needs at times a restraining hand in this direction. The architect may require advice at times as to the best construction to be used, and though, should anything happen to the building through faulty construction, the first responsibility is the architect's, the builder would not be guiltless of contributory negligence if through ignorance or carelessness he had failed to see what was amiss. Then the builder should have some acquaintance with the Building Acts and the various by-laws of the central and local authorities. The responsibility of meeting their requirements is always thrown upon his shoulders, and his task is not rendered any more easy by the anomalies and inconsistencies of which they are full. His more immediate duty on his visits will be to see that the jobs are being kept well supplied with materials. In this matter he should be very careful to look ahead. Foremen are too apt to imagine that if they give an order it can be executed the next day: but the builder who waits for his foreman to order the material will find his jobs standing still for lack of them, and it often means that, while waiting, men have to be taken off from one piece of work and put on to another—a very ready way of mounting up the cost of a job.

Defective Materials. Then he will be sure at times to have to deal with the question of bad material. He will come round to his job one day to learn that the clerk of the works has condemned the bricks or timber as not being up to specification, and he will have to determine promptly by personal inspection whether the clerk of the works is justified or whether he thinks the material good enough to defend. In the case of bricks it is usual to deposit with the architect at the beginning of a job a fair average sample of the bricks to be used, and by this sample the builder should bind his brick merchant, ordering his bricks from it. This course allows a fairly wide latitude, for bricks must be judged in the bulk, and what the builder has to determine is whether the bricks condemned have been so because of a few bad ones, or because they are, as a whole, below sample. In the latter case he is without defence, and he will be well advised if he has one load of bricks condemned to warn his foreman not to take in any more of them on the job unless they are up to sample. His position with the brick merchant, if the bricks are really bad, will be much stronger if he refuses to have them unloaded.

The question of timber will be a far more difficult one. It is usually specified to come from certain ports—in some cases, even, from ports whence timber has ceased to be imported for several years. The builder's best course is to inspect the timber in the docks before he buys it, and satisfy himself that it is up to his requirements. But really good timber is getting scarcer and dearer every year, and he will often have to be satisfied with the second best. If his timber is condemned and he is convinced that he cannot defend it, his best course is to take it off the job at once. That is not to say that he is always to give in; for if he have the misfortune to meet with a clerk of the works who has a passion for condemning everything both in material and workmanship it will be advisable to take up a firm stand from the first.

Speed of Work. But above all, the builder should carefully watch the progress of his jobs, and see that he is not getting behind his contract

time. It is true that penalties for time are rarely enforced, because there are so many contributory causes of delay—besides, possibly, the builder's lack of energy—that enforcement is found impossible in practice; but, in any case, slow work in these days is bad for the builder's reputation, and his pocket. It is a matter for discussion whether buildings were not better built when they were erected calmly and without hurry than they are in these days of rush. But the builder today has no time to stop and discuss this; he must move with the times, or he will soon cease to do building at all. But while taking care that his jobs are being pushed on as rapidly as possible, he must see to it that they are not crowded with men, or his cost book will be anything but pleasant reading. Besides his ordinary visits the builder should make a point of sometimes visiting his jobs at the time of starting in the morning; foremen want keeping up to the mark in the matter of time, and a late foreman means little work done before breakfast.

Foremen. The choice of the right men to carry out his work is a matter of great importance to the builder, and very much depends on the foremen he employs. The chief requisite in a foreman is the capable management of men; he must not only have a first-rate knowledge of the best means of carrying out work, but he must also be able to drive his workmen and get the most out of them he can, consistent with safe construction; and for this reason a foreman should be allowed a free hand in the choice of his men, with a few obvious limitations. Should a man be taken on at a job whom the employer, from previous experience, knows to be a bad workman, the builder must, of course, tell his foreman that he cannot have the man on his works; but apart from such exceptions the builder should not interfere with the men the foreman chooses, and if he has cause to feel dissatisfied with the men employed on the job, and should the results convert that feeling into conviction, the only way is to get rid of the foreman. It is almost unnecessary to say that a foreman must be sober and honest, straight not only to his employer, but to his employer's clients. A man who is dishonest towards the clients will, in the end, be dishonest towards his own employer. A builder should see that he makes his own interests and the foreman's identical; this can be assured by giving the foreman continuous employment, and keeping him on even if for the moment another job cannot be found for him.

Bonuses. Another method by which a foreman can be induced to take a serious interest in his work is by offering him a bonus at the end of the job should it come out on the right side; but this wants careful consideration, and special care should be given to the foreman's character if this bonus is offered. In these days of cutting prices, where work is too often taken below cost price, it is a temptation to a foreman to make the job pay by scamping the work. How far should a foreman be trusted is a question that builders are always having to put to themselves. Should a foreman be allowed to pay wages himself, or ought it to be the invariable rule that somebody from the office should pay? In the case of small contracts, where the wages are not heavy, the foreman may be trusted to pay, but only, of course, provided that the builder has had him in his employ for some time, and is convinced of his trustworthiness and honesty. But with contracts of any size, it is the rule for the builder himself or a clerk from his office to pay at the job. One other piece of advice may be useful—don't dismiss your foreman for trivial reasons. The old-fashioned method was to send a man away at once if you had the slightest disagreement with him; that method is happily passing away, experience having proved that a man who is always in fear of dismissal does not make a good servant.

Employer and Workmen. The growth of trades unionism and the combination of both masters and men had led to the hope that the development of better feeling between employers and workmen thus engendered would reduce to a minimum the danger of strikes. This hope has not been realised, and the building trade, like many others, has suffered during the last year or two from spasmodic and unauthorised strikes. Such outbreaks are often due to temper on both sides rather than to any grievance that could not be dealt with in the council chamber; and it is to be hoped that their folly and uselessness will lead to their abandonment as a method of settling disputes between capital and labour.

The Attractions of the Building Trade. It may, perhaps, be asked, can building, under modern conditions and modern competition, be made to pay? There is no reason to the contrary if the builder will face these modern conditions with courage and wisdom, and not be in too much of a hurry to get rich. It ought to be an axiom, but is not, that no builder should take work below cost price; and if for the time he finds it impossible to compete with modern prices, he had better hold his hand. It is better to play in the streets than work at a loss, and continual lowering of prices will tell its own tale in the Bankruptcy Court. Let him keep his head, get what little work he can at a fair profit, and not plunge by taking large contracts at impossible prices.

With all its drawbacks, one charge cannot be brought against the building trade—lack of interest. At the end of most careers a man can only point to the amount of money he has made as evidence of his work. The builder leaves a far more enduring mark behind him; and though not, of course, sharing the artistic honours that fall to the architect, he is essential to his work, for without him the architect's ideas would find no permanent or concrete expression. For this reason, to say nothing of others, no builder who honours his business should consent to have anything to do with scamping methods, or to take work at so low a price that no profit can be made without seriously deviating from fair workmanship. And here architects may well be asked to lend a helping hand by refusing to hold out to their clients delusive hopes as to how cheap work can be done.

Building Abroad. In the details of building operations and methods there is room for much diversity, and practice is regulated by climate, customs, and materials.

This course has of necessity, in considering the detailed methods of building construction, dealt with their execution as carried out in England. To a great extent, in many of the trades the practice is much the same in the whole of Greater Britain and America; and either an architect or a builder who had received an efficient training in his own country, though he would find—especially in the details of practice—divergencies from what he was accustomed to, would in a very short time readily adapt himself to them.

R. Elsey Smith and R. L. Roberts

Waves and Wave Measurement. Aerials. The "Earth." Tuning of Sending and Receiving Circuits. Resonance. Transformers. Marconi Rotating Spark-Gap. Air Condensers.

WIRELESS TELEGRAPHY

WIRELESS telegraphy, or radio-telegraphy, is a system of signalling from place to place without connecting wires, and is accomplished by means of electric—or Hertzian—waves, propagated through a medium termed the ether.

The problem confronting electrical engineers has been to devise apparatus capable of sending out or transmitting electric waves through the ether, and of collecting, receiving, or detecting at a distance the waves so sent out.

Hertz's Discovery. The first step in this direction was taken by Heinrich Hertz. In 1879 the Berlin Academy of Science offered a prize for researches into certain effects of electromagnetic forces, and Heinrich Hertz, the man who "discovered" wireless telegraphy, made some experiments—the principles of which Mr. Marconi was the first to apply to actual practice—in this connection which ultimately led to his causing electrical discharges in Leyden jars to be responded to or "answered" by similar Leyden jars between which there was no connecting wire. The famous researches of Hertz began about 1887, and later he produced an oscillator which sent out ether waves that were received and responded to by a resonator—the germ of the tuned sending and receiving stations of today. [See page 3592.]

The Commercial Development of Wireless. The discovery by Branly of the coherer was the forerunner of the first commercial means of receiving wireless signals, and for some years improved coherers were used in the receiving apparatus of the various Marconi stations.

The work of Ducretet, of Paris, who pointed out the importance of having the sending and receiving stations tuned by means of inductances, was a great forward step in promoting efficiency; and then the efficiency of transmission and the delicacy of reception improved by leaps and bounds, owing to the splendid work of Mr. Marconi and the various scientists and engineers who concentrated their attention on wireless matters.

The work of Sir Oliver Lodge, Professor Branly, and the many other scientists who carried out experiments with electric waves all contributed to progress, and have proved of immense value. But from a practical or commercial standpoint we must consider the beginning of wireless as dating from 1896, when Mr. Marconi first came to England and carried out his experiments at Westbourne Park. A year later he gave a demonstration on Salisbury Plain, carrying out communication over a distance of four miles. In December, 1898, the distance was increased to twelve miles, and in 1899 to thirty-six miles. Two years later, Mr. Marconi succeeded in signalling to St. John's, Newfoundland, from the Poldhu station, in Cornwall, a distance of 1800 miles; and recently he received signals, on a vessel fitted with a high aerial wire suspended from a kite, over a distance of 6000 miles.

The progress that has taken place, however, is not by any means confined to the distances involved; the methods, apparatus, and, above all, the efficiency obtained nowadays make the progress of this new science seem almost phenomenal. Today we telegraph by wireless from aeroplanes, airships, trains, submarines, and mines; we can work "duplex"—that is, send two messages simultaneously over the same apparatus—while the knowledge we have of the mysteries of wireless is extraordinarily detailed, though by no means complete.

There are, of course, various systems at work, the Marconi system being the foremost, but the Australian Commonwealth has its own system; the Danish system of Poulsen is at work at the Panama Canal, and there are various methods of wireless at work in America, France, Germany, and Italy. The principal features of the chief systems are briefly described in this course.

Hertzian Waves. The most important of Hertz's experiments, from our point of view, was that by which he proved the existence of radiation. The reader of the course on ELECTRICITY will recall that he fixed two metal balls near one another [Fig. 258, page 3595], and the balls were each connected by rods to a metal plate or sphere, which acted as the coatings of a condenser [see page 3350]. By applying positive electricity to one plate and negative electricity to the other, the plates were each more and more charged with electricity until they broke down the air-resistance between the balls, and a spark flew across the gap. It has been explained in page 3475 that when a condenser is suddenly discharged, the effect is oscillatory, and after the first passage of electricity each plate or sphere becomes charged with the opposite kind of electricity, and this is again discharged, and so on. The electric charge rushing backward and forward in this way is due to the rapid vibrations of free electrons, and any oscillatory movement of electrons results in the setting in motion of the ether. This motion is a *wave-motion*.

Hertz was able in the course of his experiments to discover this wave-motion, and subsequently to show how interference could take place as it does with light-waves. He used a ring of wire split at one point, the two free ends terminating in little balls [1]. When the oscillator above described was at work, Hertz found that the ring resonator would respond, and that

electrical vibrations would be set up in it, which caused tiny sparks to fly across the gap between the little balls.

The Ether a Medium for Wave-Motion. The ether, or æther [see page 740,] may be defined as that infinitely tenuous medium which fills all interstellar space and permeates all matter. It cannot be isolated or detected in any direct manner, but it is known to be inert and elastic, offering very little frictional resistance to heavenly bodies, and permitting the transmission of light, heat, and electric waves from the sun to the earth in about eight minutes. The ether is essentially a non-conductor, or dielectric, for these electric waves cannot travel in a conductor, and therefore cannot be propagated through water, and only indifferently through earth or rock; but through brick walls, wood, stone, and similar non-conductors which shut out sound and light, wireless waves and disturbances are able to travel.

Any disturbance in an elastic medium causes a wave-motion, which travels away from the point of disturbance through the medium.

Wave Motion. If a pebble is dropped into water, a circular ripple is caused, and this ripple travels along, going outwards in all directions, so that the circle quickly increases in size. The water acts as a medium through which the wave-motion is propagated.

The ether is the medium which, in the case of wireless telegraphy, replaces the water in the case of the ripple; the wave-motion is set up and produced by the oscillatory agitation of the electrons, as the experiments of Hertz showed, and this wave-motion, electro-magnetic in character, takes place in the ether, the waves travelling at about the same rate as light—that is, about 185,000 miles a second. They can also be reflected like light-waves, for Hertz found that by reflection he could get a "crest" of one wave to interfere with the "hollow" of another, and so prevent his ring resonator from sparking.

Professor Fleming has aptly described electrons as strain-forms or centres from which twists start, and the energy exerted by a twist is propagated through the ether. Very rapid alternations of electric current, such as we are dealing with in wireless telegraphy, cause the electrons to jump backward and forward with great rapidity, and the shock resulting will cause vibrations that will carry energy through the ether for long distances. A piece of elastic extended and let go of gently will do nothing, but if pulled out of shape and suddenly released it will produce great energy, as in the case of a catapult. The ether disturbances produced by the sudden electrical discharge of the condenser and the sudden "twistings" of the ether are somewhat analagous.

Measurement of Waves. In any train of waves the *length of a wave* is the distance between any point in that wave and a corresponding point in the wave behind or before it. Thus, for instance, the distance between the crest of one wave and the crest of the next is the length. This is commonly indicated by λ, and measured in metres.

A complete wave is measured from crest to crest, and the *amplitude*, indicated by a (Greek *alpha*) is the perpendicular distance from the highest point of the crest to the lowest point of the trough. The number of complete movements of a wave, or oscillations per second, is termed its *frequency*.

It must be noted that though the amplitude of a wave is steadily decreasing as the distance from the point of origin increases, the length of the wave remains the same, whatever its distance from that point. The speed, too, remains the same, whatever the size of the waves.

The velocity of a wave is the product of the number of oscillations per second and the wave-length. Thus:

$$V = n\lambda$$

where V = the velocity in metres, n = the number of oscillations per second, and λ = the wave-length in metres.

The behaviour of waves will be readily understood if we return to the experiment of the stone being dropped into a pond, and watch the outward travel of the ripples: we see that they gradually become smaller, and finally die out. The ether waves behave in the same manner, as, by travelling outward and thus spreading, their energy is distributed over an ever-increasing area, quite apart from the question of the energy being absorbed or dissipated in other ways. Taking the water-ripple as analagous, its *amplitude* would be measured by the maximum distance between the top of a crest and the bottom of the corresponding hollow—that is, AB in Fig. **4**. The amplitude of the next wave, CD, would be less, and so on until the wave died out.

The amplitude of the electro-magnetic wave similarly decreases, and the ratio of the successive amplitudes give us the *decrement*. At each discharge of the aerial a group of oscillations is sent out, and the number of waves in a *train* depends on the decrement.

Symbols. In diagrams illustrating wireless telegraphy circuits, a number of symbols are used to indicate the component parts of the apparatus. The more important of these are illustrated in the accompanying diagram [6].

The Induction Coil. Modern wireless telegraphy depends upon the radiations or ether-waves sent out into space from an aerial wire, or antenna. High voltages are employed, and these voltages are obtained by transforming up the low-voltage currents ordinarily obtainable. The most usual transformer, though not the most efficient, is the induction or Ruhmkorff coil, and it is used in many ship-stations, in the emergency sets on large ships, and almost invariably by amateurs for their private stations

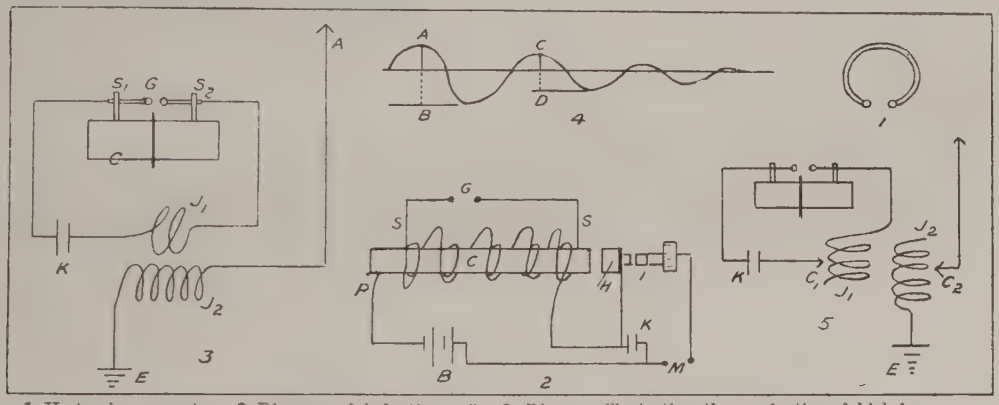
The induction coil consists essentially of an iron core, round which are wound two coils, one of thick wire and few turns—the *primary*—the other of very fine wire of many hundreds of thousands of turns—the *secondary*—and a means of rapidly and abruptly interrupting the current flowing through the primary coil. In the case of a coil such as would be used on board a ship, capable of giving a spark ten inches in length between the secondary terminals, we

should find the core, or bundle of fine iron wires, wound round with two, or perhaps three or four, layers of thick, insulated copper wire; over this a thick ebonite tube, and over the tube perhaps ten miles of fine, silk-covered copper wire. The secondary coil is wound in several sections, and is thoroughly impregnated with paraffin wax in order to render the insulation sufficient to withstand breakdown. In many modern coils the primary is also divided, and the different layers can be coupled up in parallel or series, according to the type of spark required.

The induction coil is shown diagrammatically in Fig. 2. B is a battery supplying current to the primary coil, PP, wound round the iron core, C. SS is the secondary coil, and G the spark-gap. I is the interrupter, on the smooth running and regulation of which much depends in wireless work. M represents the Morse key. When M is tapped, contact is made and current flows through the primary via the interrupter. H is a hammer of iron, which is now attracted by the core, C, which is magnetised owing to the current in the primary. On H being attracted, however, contact is broken at I, the magnetisation ceases, and H flies back again, contact is remade, and so on. K is a condenser, usually of about two microfarads capacity, consisting of alternate layers of tinfoil and varnished paper. At each interruption of the current the number of linkages of lines of force is varied, and an induced electro motive force is produced in the primary tending to oppose the change of current. The important effect of the condenser is to take up the induced electromotive force, and thus interrupt the primary current more suddenly. As a result, a higher electromotive force is induced in the secondary. The condenser, besides accelerating the break of the primary circuit and holding back the current when contact is made at I, greatly helps to eliminate sparking at the contacts I.

In using an induction coil for wireless work, these contacts must be frequently filed flat, as the sparking produces burning and liability of fusion and resultant short-circuiting.

We shall now see how, with the high voltage produced by the induction coil, we are able to produce the high-frequency oscillations necessary to produce ether-waves. In Fig. 3, C represents the induction coil, S_1 and S_2 representing the terminals of the secondary coil. G is the spark-gap; and if we assume that the coil is capable of giving a ten-inch spark in air, the brass balls of the spark-gap would probably be placed about one inch or one inch and a half apart, as the oscillatory spark used in wireless is far more intense and much shorter. The spark-gap is connected in shunt with a condenser, K, and an inductance J_1, the latter consisting of two or three turns of heavy copper or aluminium wire about a foot or more in diameter. When the induction coil is operated by the key, a spark flies across the gap G, and the condenser K discharges itself, and, the discharge being oscillatory, a very rapid series of sparks takes place, the time (T) between each maximum charge of the condenser being given by $2\pi\sqrt{LC}$, where C is the capacity of the jar and L the self-induction of the coil J_1. The coil J_2, consisting of several turns of wire of smaller gauge than J_1, is inductively

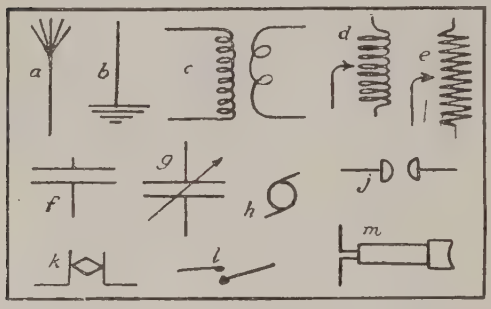


1. Hertz ring resonator 2. Diagram of induction coil 3. Diagram illustrating the production of high-frequency oscillations 4. Diagram illustrating the amplitude of waves 5. Diagram illustrating alteration of wave length

effected, and the electric oscillations of the primary circuit are imparted to the secondary circuit, this consisting of the coil J_2, the aerial wire A, and the "earth," E. This circuit, the capacity and inductance ($L \times C$) of which must be equal to, or a simple multiple of, the LC of the primary circuit, is excited by the latter, and electromagnetic waves are set up in the ether by the rapid alternations of potential along the aerial A. The condition for the discharge of the primary circuit being oscillatory is that its resistance must not be greater than $\sqrt{\frac{4L}{C}}$

Wave Length. Wave length is dependent on the frequency of the oscillations. The frequency can be measured, or it can be calculated from a known expression, $n = 160{,}000/\sqrt{CL}$, C being measured in microfarads and L in microhenries; if we call it n, then assuming the ether-waves to be propagated with the same velocity as light—say, 185,000 miles or 300,000,000 metres per second—we can find the wave length from the formula for wave velocity previously quoted, by dividing this velocity by n. In other words, the wave length $\lambda = \frac{300{,}000{,}000}{n}$ metres. It will be

seen that the greater frequency of the oscillation, the shorter is the wave length. The longest wave made by Hertz in his experiments was about nine metres, but with modern apparatus waves of about 9000 metres have been produced. The wave length generally employed today in ship and shore station equipments is 300 or 600 metres, but special stations for long-distance work use waves varying from 1000 to 8000 metres in length. The path of these waves is probably in a non-conducting atmosphere between the surface of the earth and a boundary some thirty or forty miles above it.



6. SYMBOLS USED IN WIRELESS TELEGRAPHY

a, aerial wire or antenna; *b*, earth connection; *c*, induction coil or transformer; *d*, coil in which the inductance can be varied; *e*, coil in which the resistance can be varied; *f*, condenser having quality of capacity; *g*, condenser of variable capacity; *h*, direct current dynamo; *j*, spark-gap; *k*, crystal detector; *l*, Morse key; *m*, telephone

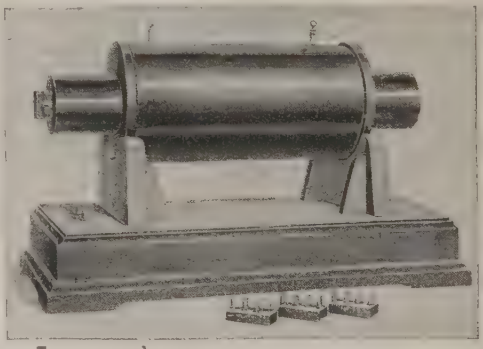
Alteration of Wave Length. We have seen that the wave length λ depends on the capacity and inductance involved. Hence, by varying these factors, we are able to change the wave length. Thus in Fig. 5 C_1 and C_2 are sliding contacts arranged so that C_1 can be attached to different turns in the primary inductance, thus allowing a different amount of inductance to be included in the oscillatory circuit. C_2 can similarly be coupled up with different turns in the secondary inductance, as whenever J_1 is varied, J_2 must be varied in order to get the two circuits into resonance.

The Aerial and its Function. We have already made mention of the *aerial* and the *earth*. The aerial, or antenna, has two functions—to transfer the energy of the transmitter to the ether in the form of electric waves, or to absorb or collect it from the ether for use in the receiver. It consists sometimes of a single wire, but more generally of parallel wires or a system of wires (radiating, perhaps, in the manner of umbrella ribs) supported by a mast high above the ground and well insulated at the supports with ebonite, porcelain, or some other suitable substance, the end being attached to one side of the spark-gap of the induction coil or to one end of the inductance coil. Stranded copper or bronze wire, size 7/20, makes a good aerial. It may be protected from the weather and its capacity increased by an enamel.

The form the aerial takes is, of course, largely dictated by the area at disposal. A single air-wire held by an insulator from a mast is of little use except for very short distance work. The form largely favoured in medium-powered stations is two or more wires in parallel between two masts. By increasing the number of wires in an aerial the capacity is increased, but to secure the increased capacity that parallel wires give they should be well separated. The higher they can be placed above the ground the better, 30 ft. being not too high for a small station. The sectional steel masts of long-distance stations tower 200 to 450 ft. above the earth. The distance between the masts should also be long—over 100 ft., if possible, for a small station—for the longer the wires the greater the inductance of the aerial.

At the coast stations of the Marconi system there is usually one high central mast, with an umbrella aerial connected to four subsidiary masts. This permits good, all-round working. But where communication is desired in a special direction two or more masts are used, placed in positions best suited to the employment of the directive aerial principle [see later]. On board ship the usual fashion is to suspend the wires horizontally between the masts.

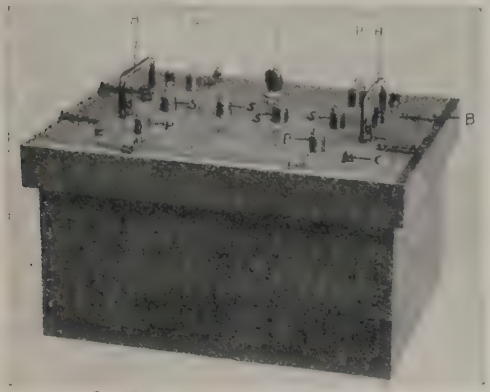
Earthing. Whether an aerial should be *earthed* or not has provoked considerable discussion. Earthing is adopted in all Marconi stations; indeed, "the most important feature of Mr. Marconi's first patent was the earthed aerial—that is, the aerial connected to ground directly or through capacity, so that by virtue of the conductivity of the earth's surface, and the consequent imaginary aerial therein, the true aerial became twice as effective as that of a similar aerial entirely dependent on the earth's surface." Generally, an earth connection is made by laying a number of wires



7. WATSON'S INTENSIFIED INDUCTION COIL

or copper strips just under the ground, radiating in all directions—the farther the better—from the station. A connection is formed at the junction of the wires, and leads into the station, where it is attached to the side of the spark-gap opposite to that which is connected to the air-wire, or to the end of the inductance as shown in Fig. 5. In the earth employed in Marconi stations conducting plates are symmetrically placed round the station and connected up by radial conductors, the power of the station and the nature of the ground determining the extent of the earth. In some cases, such as

military stations, where the character of the ground makes it a matter of difficulty to bury the earth, wires or wire netting may be simply laid or stretched over the ground, and connected to the earth side of the transmitting or receiving apparatus. After this manner is the Fessenden "wave-chute," an American invention. On



8. 1½ KILOWATT TRANSFORMER

b, bolts for fixing lid to container; *c*, bolts for holding coils in position; *h*, iron lifting-handles; *o*, wooden plug for oil inlet; *p*, primary winding terminals; *s*, secondary winding terminals.

board ship earthing is effected by connecting to the hull of the vessel.

Briefly, it may be said that it is claimed for earthing that it greatly increases the distance over which messages can be sent and received though Sir Oliver Lodge contends that the, earthing of an antenna militates against sharp tuning.

Directing the Waves. The waves travelling from the antennæ radiate over the earth's surface much as the water falls round a fountain on a still day. Consequently, if communication is taking place between two stations only, a great deal of the energy which it is desired to confine to a particular route is wasted. The problem thus arose of keeping the waves to a definite path, like the rays of light directed from a searchlight.

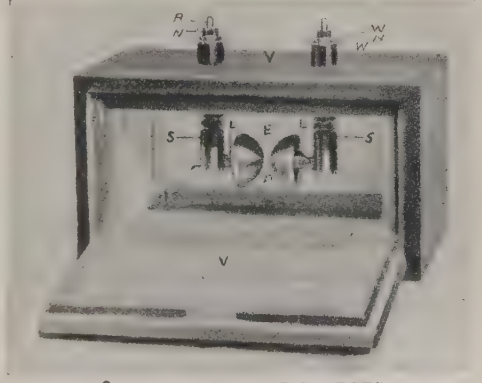
Hertz, using waves two or three feet in length, demonstrated that cylindrical parabolic mirrors caused electric radiations from an oscillator to be reflected and converged; and Marconi, over a short distance on Salisbury Plain, was successful in focussing such a beam on a distant station, the application of the idea being a feature of his first British patent in wireless telegraphy. It is essential, in the case of wave motion, that the mirror be large in comparison with the wave length; and hence, as the wave lengths necessary to cover long distances must be large—possibly up to several hundred metres—the use of mirrors becomes quite impracticable for the purpose of reflecting and converging them.

Marconi, in the course of his experiments, noticed that if the vertical air-wire is bent at the top parallel to the ground, the waves are sent out most strongly in the direction opposite to which the wire is bent; or, taking the letter T as an illustration, if the wire is bent to the left arm of the T, the greatest wave-flow is in the direction of the right arm of the T, and vice versa. This is the principle of the Marconi *directive aerial*. Marconi also found that if the receiving antenna is bent in a direction away from which a message is coming, the signals are greatly improved in strength. Therefore two stations are in the best condition for intercommunication when their antennæ point in opposite directions. The explanation of Marconi's discovery is that the lines of magnetic force stretch out farther into the ether in the direction opposite to which the antennæ point, and so give the greatest radiation in that direction. The area of minimum radiation is approximately at right angles to the line of maximum radiation.

The method of finding the direction from which signals are arriving is dealt with later.

Damped and Undamped Waves. Every wireless system aims at the transmission of more or less continuous waves, as the greatest efficiency is obtained in this way. But a very large number of stations working at the present time depend on either an induction coil or a high-tension transformer to produce the high-tension current; and the electric waves produced by these methods are not continuous. A series of short wave-trains are sent out from the aerial or antenna, and these waves are *damped*—that is, each wave-train rapidly dies out. If, however, one wave-train follows the next with very great rapidity, the result tends to become equivalent to a persistent train of waves, and this effect is very successfully produced in the larger Marconi apparatus as used for long-distance transmission.

The Transmitter. The simplest type of wireless transmitter is that dependent on an induction coil, such as is used in the Marconi



9. FIXED TYPE DISCHARGER

e, cast iron electrodes; *l* and *n*, lock nuts; *p*, protective spark points; *r*, brass rod; *s*, ebonite pillars; *t*, zinc tray; *v*, chamois-leather-covered vent holes; *w*, brass washers.

Figures 8 and 9 are by courtesy of the Wireless Press, Ltd.

"emergency set." The induction coil is supplied with current from a battery of accumulators, and in the emergency set is used simply in connection with the aerial—that is, without a transformer. But a large number of stations are equipped with a coil, condenser, and transformer,

and are capable of a range of about fifty miles by day, and considerably more by night. In larger stations the induction coil is replaced by a static transformer [8]; the secondary of the transformer is connected with the fixed type discharger shown in **9**.

The Oscillation Transformer. The transformer, often known as a *jigger*, plays a very important part, not only in the tuning, but in getting the circuit shunted off the spark-gap into resonance with the circuit comprising the aerial and "earth." In Fig. **10** the spark gap, S, is shown connected up in the circuit containing the condenser, K, and the inductance coil, J_1. J_2 is another coil, of more turns of thinner wire, and J_1 and J_2 form respectively the primary and secondary coils of the *high-frequency transformer*.

Iron cores greatly increase the efficiency of transformers, by increasing the intensity of the field, as will be gathered from the chapter on Transformers in ELECTRICITY. But here the high frequency of the currents and the *hysteresis* of the iron—its tendency to be slow or to "lag" in becoming magnetised when the magnetising force is at its maximum, and similarly to lag in losing its magnetism when that force is reduced to zero—render the use of iron impossible, so that the wireless transformer resolves itself into two simple coils, separated by an air space, and placed closer together or farther apart according to the nature of the coupling desired. *Coupling* denotes the proximity of the coils to one another; it is *loose* if the coils are far apart, and *tight* if they are close together. One coil, the primary, may consist of two or three turns of wire, perhaps 18 in. in diameter; the secondary of five to twenty turns of thinner wire, of the same diameter.

In Fig. **11** is seen an *auto-transformer*—that is, one coil only is used, *xy*, representing the primary, and *zy* the secondary. This is the tightest coupling possible.

For the greatest amount of current to be induced in the secondary, the oscillation constants of the primary and secondary circuits require to be equal. Thus, as the *oscillation constant* (O) depends on the product of the capacity of the condenser and the inductance in the circuit ($K \times L$), it can be varied by varying the condenser, K, or the number of turns in J_1. Or if K and J_1 are fixed, we can vary J_2. The aerial, A, has, of course, both inductance and capacity.

When the two circuits are in resonance [see page 3475], the maximum effect will be produced. If an incandescent lamp be placed (shunted) across a part of the secondary circuit, and K or J_1 be varied, it will be found that the lamp will glow with varying degrees of brightness; the glow will be brightest when good resonance has been obtained.

Aerials and Wave-lengths. The natural wave-length of the aerial is something between four and five times the actual length of the aerial. Where, as is often the case with small experimental stations, the aerial cannot be made very long, a good deal of inductance in the secondary of the transformer has to be introduced; thus in Fig. **10** the number of turns in J_2 would be increased. Where, on the other hand, the aerial is too long for the wave-length in use, as is sometimes the case in big ships when working temporarily on a short wave, it is necessary to put a condenser in series with the aerial, so as to *decrease* its capacity, thereby increasing the oscillation frequency. The velocity of the waves, V, is fixed (185,000 miles per second), and is equal to the product of the wave-length and frequency of the oscillations, according to the equation $V = n\lambda$, but as $n = \frac{1}{2\pi\sqrt{LC}}$ anything that is done to lessen the inductance or the capacity will increase the frequency, and lessen the wave-length.

Coupling for Sharp Tuning. The coupling of the primary and secondary of the transformer is an important matter, as when correctly arranged the tendency to emit two distinct wave-lengths which exists is minimised. The looser the coupling—that is, the less inductive effect of the primary on the secondary—the greater is the *selectivity*; or, in other words, the sharper the tune obtained. This sharpness, being obtained at the expense of the inductive effect, is bad from the point of view of efficiency, and the radiations emitted by the aerial are weak. When the maximum radiation is required, the coupling must be close, although the tune of the waves will not then be so sharp, and interference by another transmitter is less easy to avoid.

The coupling is varied very ingeniously in some transmitters by means of a hinged pair of coils. One arrangement is shown in Fig. **12**, where J_1 is the primary, J_2 the secondary, and S is a side-strut by which the two can be clamped at any desired angle.

Quenched Sparks. As regards the actual form of the transformer, it has been found that there is no advantage in having more than one turn of wire in the primary coil, though two are often used. The secondary coil usually consists, in the Marconi transformer, of five to twenty turns. In a closely coupled transformer the secondary is usually wound over or under the primary, and to secure good insulation the whole transformer is sometimes immersed in oil. With close coupling and good radiation resulting, there is, as already observed, the trouble that waves of two frequencies are produced; and as only one is detected and used in an ordinary receiving-station, there is a loss of energy.

This dual frequency, resulting from the inductive effect on the *primary* of the current induced *by* the primary in the secondary, has been successfully eliminated by means of what is known as *shock excitation*. Rapidly *quenched* sparks in the primary circuit have been found to produce rapidly recurring trains of oscillations in the secondary of a uniform, and not dual, wave-length. The oscillations in the primary circuit, owing to the quenched spark, are damped out too rapidly for the reaction between secondary on primary to take place.

The quenched spark is a feature of many modern systems of wireless telegraphy. A blast of air across the spark-gap, for example, will blow away the conductive gases produced by the spark, increase intensely the resistance of the gap, and prevent the recurrence of the spark, and thereby the oscillatory effects on the primary circuit.

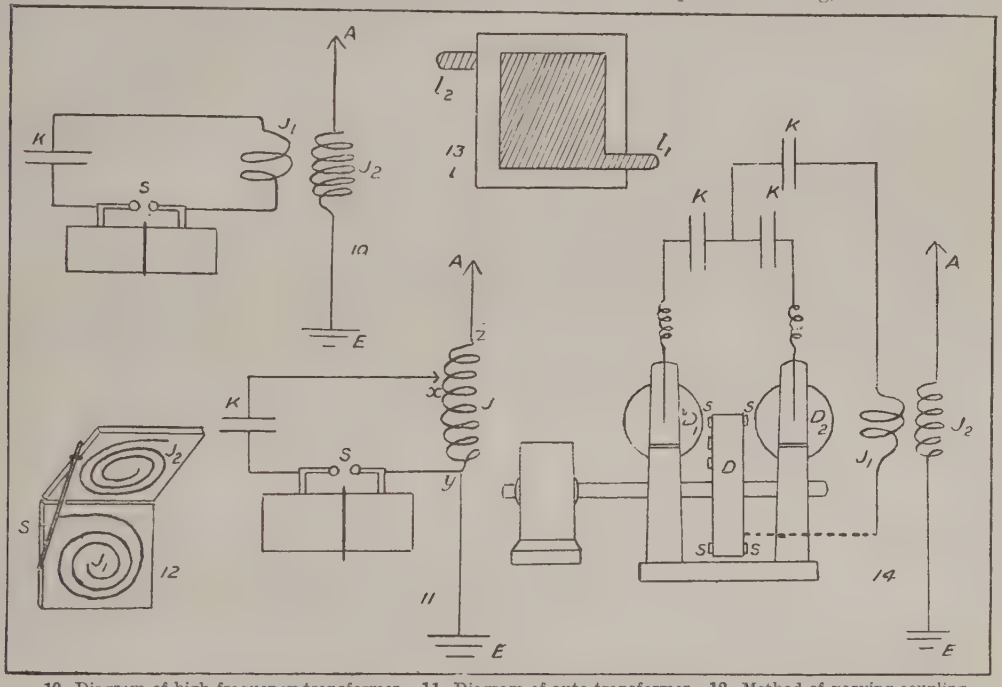
Very smooth and absolutely parallel metal plates are used by Von Lepel, Galletti, Count Arco, and others in the production of quenched sparks. Each plate is separated from the next by mica or paper rings, about one-tenth of a millimetre only in thickness. The plates are kept cool by water or other devices, or by irradiating flanges. By having a number of these plates held together, very numerous spark discharges take place, each spark being instantly quenched, but each giving rise to a quickly damped condenser discharge.

Wave-trains are generated in this way which produce a more or less continuous stream of waves, and a high efficiency results.

Marconi Rotating Spark-gap. It will be interesting at this stage to describe the rotating spark-gap used by Mr. Marconi, by which something of the same kind is produced. One type of discharger is the studded disc pattern. Direct current from a dynamo or battery of storage cells is converted into alternating current by means of a motor-alternator, the latter having attached to its shaft a disc provided near the periphery, with a number of equally spaced studs of metal. The sparks pass during the rotation of the studded disc, D [**14**], between the studs, S S S, and rotating plane discs, D_1, D_2, on either side. Alternating current of about 20,000 volts or more is discharged in this way, and the condensers, KK, and primary inductance, J_1, of the oscillation transformer are connected up in the manner shown in the diagram.

Mr. Marconi made a further advance by employing a smooth disc in place of the studded disc, and or high-tension transformer specially constructed for the purpose. One of the many types of spark discharger is employed, and this is shunted by a battery of Leyden jars acting as the capacity, either the primary coil of a two-coil oscillation transformer or the primary *portion* of a single coil transformer completing the circuit. Flexible wires terminating in clips are used to connect up with the transformer or jigger, so that the primary oscillating circuit can be readily modified to get it into resonance with the secondary; or the wave-length can be altered.

Condensers. The condensers used in wireless telegraphy call for special description. The ordinary Leyden jar consists of a well-insulated glass tube or jar, with an outer and an inner coating of tinfoil. Flat sheets of flint glass are frequently used for larger condensers, with tinfoil sheets placed between; each plate has a lug, as shown in the



10. Diagram of high-frequency transformer 11. Diagram of auto-transformer 12. Method of varying coupling
13. Condenser plates 14. Diagram of Marconi rotating spark-gap

thus succeeded in producing a practically uninterrupted train of waves.

Sending Signals. When using an induction coil or ordinary transformer in the smaller apparatus, signals are given by pressing the Morse key, which makes contact, causes the spark discharge to take place, and thus generates a short wave-train which denotes a signal. In the case of the spark dischargers described above, the current is stopped or interrupted, not switched on, to denote the signals, and in some systems of continuous waves an alternative method is employed, which is described later, of grouping the waves into successive short groups of such frequency that a musical note is created, which is easily detected at the receiving stations.

Ship Transmitters. The transmitter frequently used on ships comprises a specially wound dynamo, which generates alternating current, having a frequency of some 300 complete alternations per second, and this is passed into an induction coil

figure [**13**], and all the lugs of alternate sheets can be connected up. Thus with ten sheets five would be five lugs arranged as l_1, and five arranged as l_2 for the two capacities of the condensers. The tinfoil sheets and glass plates are strongly bound together, and the whole "block" is placed in an ebonite or other box, and the box filled up with oil or vaseline.

Tubular Condenser. A very important form of condenser is that invented by Moscicki. It is a tubular condenser, the inside and outside coatings being of silver, or tin deposited by a special process, with the total exclusion of air bubbles. The glass tubes are made thicker at the ends than in the middles, where the dielectric strain is greatest, and the danger of the glass becoming punctured thereby minimised. The tubes are mounted in "batteries," the frame or stand being heavily insulated with porcelain.

T. THORNE BAKER

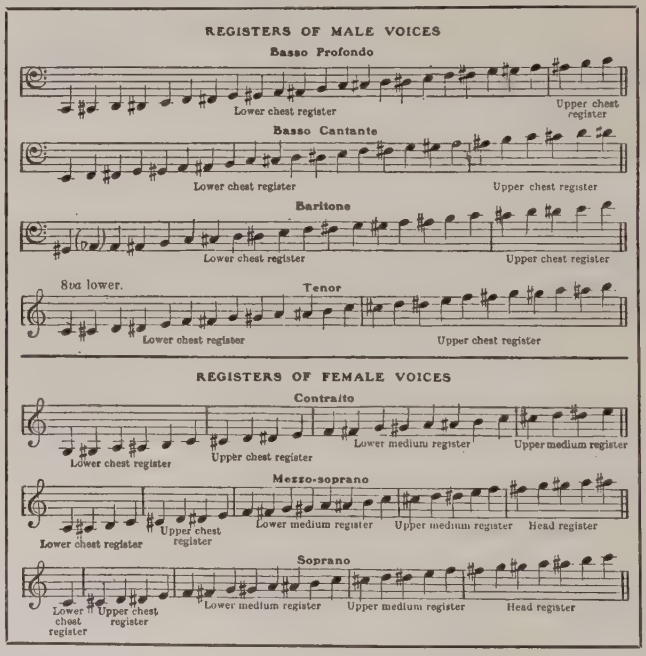
The Registers. Volume and Tone. Correct Attack. Faults to be Avoided. Exercises and How to Practise Them.

SINGING PRACTICE

THE human voice is characterised by three distinct qualities of tone, called its registers. The word "register" has been described by Manuel Garcia as "a series of consecutive homogeneous sounds produced by one mechanism, differing essentially from another series of sounds equally homogeneous produced by another mechanism, whatever modifications of *timbre* and of strength they may offer. Each of the three registers has its own extent and sonority, which varies according to the sex of the individual, and the nature of the organ."

There are three registers, called respectively:

1. Open or chest, or *Voce di petto.*
2. Closed or medium, or *Voce di gola.*
3. Head, or *Voce di testa.*

In bygone days, before the study of physiology became general, it was firmly believed and taught that the chest or open notes were actually produced in and emanated from the chest; that the medium were actually produced in and emanated from the throat; and that the head notes were produced in and emanated from the head; and owing to this belief these names, chest, medium and head, first came into use. But the student must banish this absurd idea, all the notes being produced in, and emanating from, the larynx, or voice-box. Although by some authorities these names, chest, medium, and head, are not approved of, to avoid confusion it is advisable that the student should retain them.

The first to be considered is the open, or chest register, which subdivides into the lower and upper chest registers.

The Lower Chest Register. The deepest and strongest tones of the voice belong to the lower chest register. In singing these notes the feeling is as though they were produced in the lowest part of the lungs. If the hand is lightly placed upon the lowest part of the chest, the vibrations can be strongly felt.

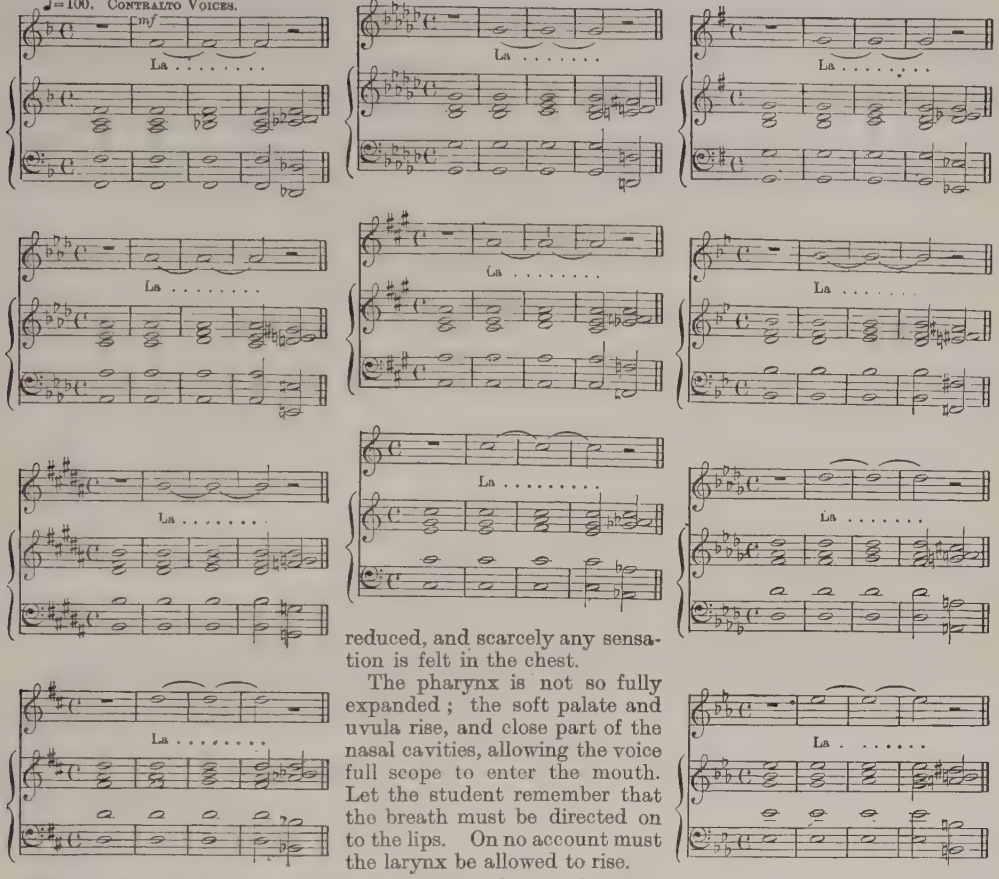
When these notes are correctly sung the whole length, breadth and thickness of the vocal cords vibrate, and the windpipe and pharynx are very much expanded. As the voice ascends the scale, the great tendency of the larynx or voice-box is to rise; this must be carefully guarded against.

The Upper Chest and Medium Registers. All that has been said with regard to the lower chest register equally refers to the upper chest register, except that the vibrations are felt a little higher in the chest, and can be easily detected if the hand is placed upon the upper part. In singing the notes of this register, the whole of the vocal cords do not vibrate. In both registers the utmost care must be used that the notes are not forced. The mouth should feel full of sound. Men (basses and baritones particularly) have better chest notes than women. In female voices, the contralto has the best chest notes; light sopranos have scarcely any.

The medium or closed register like the chest register also includes two series of tone — the lower and upper medium. Some professors call the medium voice the *falsetto*, but since the word "falsetto" refers to notes "above the natural compass of the voice," the word here is a misnomer, for the voice of the medium register is as natural as, if not more so, than that of either of the other registers.

The Lower Medium Register. The sensation felt when these notes are sung is as though the voice emanated from the throat. In singing the notes of this register the vocal cords come closer together; consequently the vibrations are quicker, the volume of tone is

Ex 1. Soprano, Mezzo-soprano, and Contralto Voices.



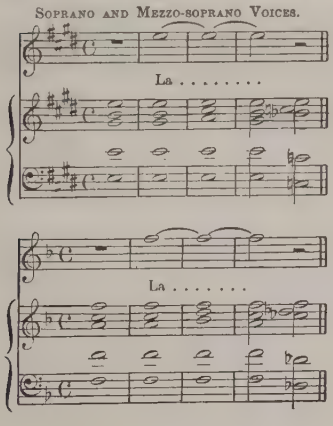
reduced, and scarcely any sensation is felt in the chest.

The pharynx is not so fully expanded; the soft palate and uvula rise, and close part of the nasal cavities, allowing the voice full scope to enter the mouth. Let the student remember that the breath must be directed on to the lips. On no account must the larynx be allowed to rise.

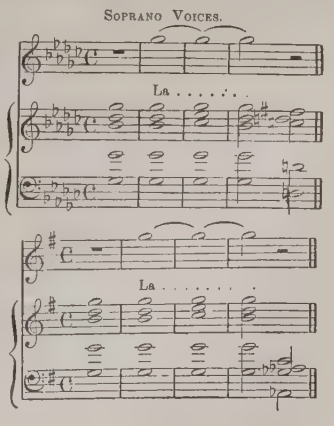
The Upper Medium Register. In producing the notes of the upper medium register the breath must be directed against the middle of the hard palate; the feeling then is as if the voice were produced in the upper part of the mouth, vibrating in the cheek bones. In singing the notes of this register also, the larynx must be kept low.

The Head Register. The sensation experienced when singing the notes of the head register is as though the sound emanated from the back of the head, vibrating in the posterior nasal cavities. The chink of the glottis is very small, the vocal apparatus contracted, and the vocal cords, being at their greatest tension, are very close together. As the student ascends the scale, the aperture or chink of the glottis becomes smaller and smaller until, finally, upon reaching the highest note, the opening is very minute. To produce these notes scarcely any breath is required, and the mouth must be kept wide open.

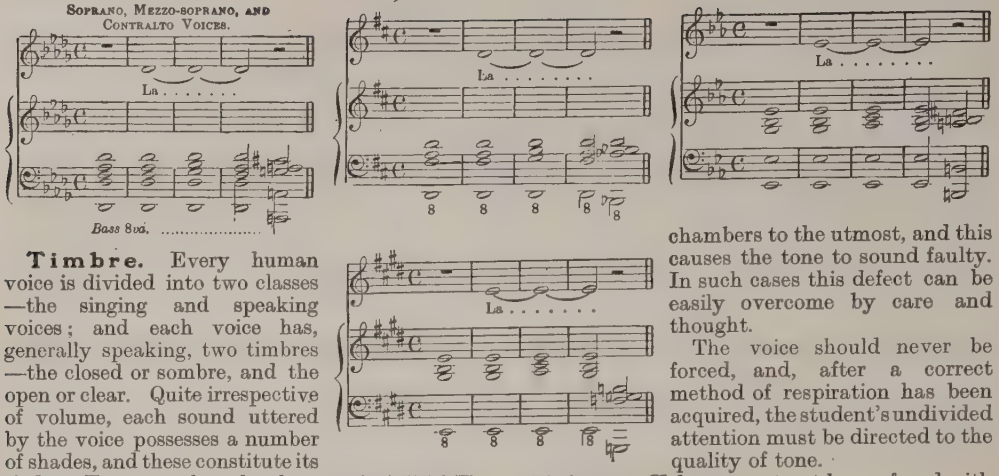
Soprano and Mezzo-soprano Voices.



Soprano Voices.



The soprano, mezzo-soprano, and tenor voices are the most noted for the head register. Occasionally one finds a contralto or baritone who possesses one or two head notes; but, generally speaking, when such is the case it is more than likely that the so-called head notes are nothing but the upper medium notes that have been trained as head notes. In this, as in the other registers, the larynx must be kept low.



Timbre. Every human voice is divided into two classes —the singing and speaking voices; and each voice has, generally speaking, two timbres —the closed or sombre, and the open or clear. Quite irrespective of volume, each sound uttered by the voice possesses a number of shades, and these constitute its *timbre*. For example, take the vowels A E I O U, pronouncing them, Ah, Ay, Ee, O, Oo. Sing or recite each of these vowels on the same note, and with the same intensity of sound, listening carefully. The *tone* of each will be found to be quite different.

Beauty and Quality of Tone. It has been said that no two voices are alike. This being so, each voice must have some special characteristic; but, besides this, it must be either resonant or muffled, mellow or nasal, clear or throaty. The student should bear in mind that the qualities which constitute "beauty of tone" are resonance, purity, and clearness.

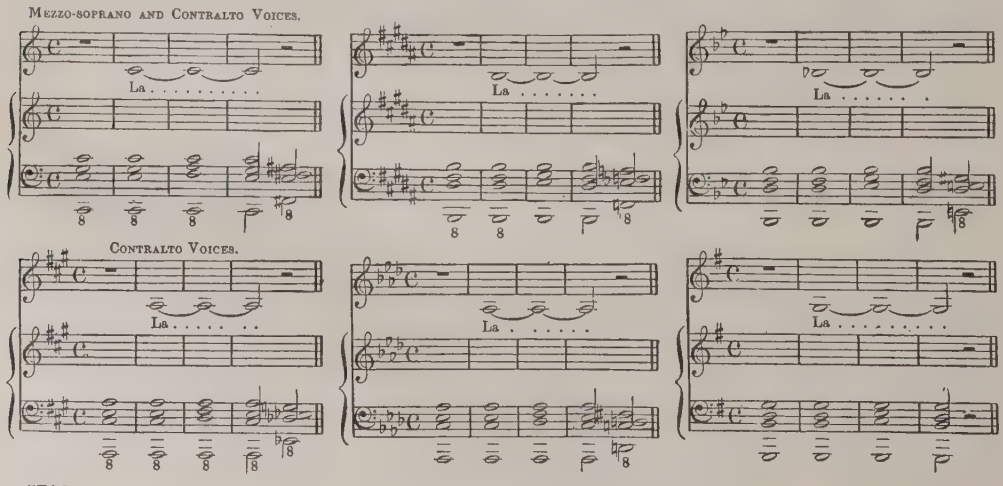
Although all tone is formed in the larynx, its quality depends almost entirely on the resonance chambers. If Nature has endowed the student with open, free, and good resonance chambers—chiefly the pharynx and nasal cavities—together with the free use of the soft palate, uvula, roof of the mouth, tongue, and teeth, it may be affirmed that the quality of the voice will be good—that is, presuming that the vocal cords are not defective. Numbers of people, some through force of habit, some through idleness, never use their resonance chambers to the utmost, and this causes the tone to sound faulty. In such cases this defect can be easily overcome by care and thought.

The voice should never be forced, and, after a correct method of respiration has been acquired, the student's undivided attention must be directed to the quality of tone.

Volume. Volume must not be confused with intensity. Volume is the size or magnitude of the voice, its loudness or softness; and to cultivate it the student must have some knowledge of, if he has not altogether mastered, the art of breathing. To acquire volume, the student must keep his larynx low, all the muscles of the throat free, the breath well under control—too much breath must not be expelled nor any undue pressure put on the vocal cords—the soft palate and uvula must be raised, the chest well expanded, and the tone directed to the front of the mouth, but there must be no forcing.

It should be noted that an intense tone is not necessarily a loud one. It is caused by the pressure of breath on the vocal cords. There are various degrees of intensity. These depend entirely upon the nature of the phrase to be sung or recited; the greater the passion to be portrayed the greater must be the pressure—but not force of breath—upon the vocal cords.

Attack. To attack a note properly is to begin it correctly, not scoop up or slur down to it, but to start it in the very centre. The breath must be well controlled; the attack must be



decided—not necessarily loud—quick and light. Signor Randegger compares it to "touch" in pianoforte playing, and he says "it corresponds to it in quickness, distinctness, lightness, and elasticity."

There is always a tendency in attacking the first note of a song or exercise to let the air rush out, leaving insufficient breath to finish the phrase. It is essential, therefore, that the whole of the vocal apparatus should be *prepared* and in readiness ere the order is mentally given for sound to be produced.

Unfortunately, "poor attack" is a very common fault with students of singing and untrained singers. This is chiefly owing to nervousness, which may cause the singer to attack the tone a little higher or lower than indicated; he will then slur down or scoop up to the correct tone; this is a general fault, but none the less bad. Sometimes a pupil through sheer fright dare not start to sing. Anyone at all afflicted in this way must exert all his will power to overcome his nervousness.

It not infrequently happens that "tightening the throat" to prevent the breath from escaping causes the attack to be incorrect. To repeat what has already been said over and over again, the diaphragm and rib muscles only—*not the throat muscles*—must regulate the breath control. Let the student remember that the attack must be distinct, decided and quick.

Faults to be Guarded Against. Some of the most general faults to be guarded against in singing are these:

1. Bad production—throaty and nasal singing.
2. Breath escape.
3. Tremolo and slurring.
4. Fatigue of the vocal apparatus.
5. Forcing the voice.
6. Tightening the throat muscles.
7. Faulty intonation.
8. High larynx.
9. Wrong position of tongue, soft palate, and uvula.
10. Facial contortions.
11. Movement of the shoulders.
12. Standing on the toes.

Bad production is due to two causes, the first of which is the root of the tongue pressing on the epiglottis, and so preventing a free passage of the breath. It is not an easy fault to overcome, so the student must exercise a good deal of will power and perseverance. Let him open his mouth naturally and fairly wide, and to see what he is doing he must practise before a mirror. Let the tongue be quite limp and lie naturally on the floor of the mouth, keeping the tip against the lower teeth. If he is not already able to keep his tongue "down," he must practise the exercises for the tongue given later.

The second cause of throaty or guttural singing is that the root of the tongue rises and forms a barrier at the back of the mouth. As the natural passage is thus blocked, the breath strikes against the barrier, and some forces its way round the sides of the tongue, some passes into the nasal cavities, and some is driven back into the throat.

When nasal singing is permitted, the tone sounds as though it were actually issuing from the nose. As a matter of fact, in certain cases some of the tone does escape through the nose. It is the result of not raising the soft palate and uvula, and the tongue at such times is often elevated at the root; in this way the breath is prevented from entering the mouth, and an undue amount is forced into the nasal cavities and nostrils. To remedy this, practise the exercises for soft palate and uvula given later on. In some cases nasal singing is due to adenoids. When such is the case, let the student see a doctor and have them removed.

Breath Escape. With beginners, breath escape is a very common fault. It is due almost entirely to a lack of proper breath management, together with a too slack tension of the vocal cords.

What actually takes place is that the breath, for want of control, rushes out through the vocal cords, which are not prepared to receive it. The result is that the greater part of the breath slips through, while only a small portion is used to make the cords vibrate; consequently the listener hears almost more breath than voice.

Let the student sing his exercises *very softly*, feeling all the time that the ribs are well expanded, and that every particle of air coming from the lungs is being used to make the note. This fault, which is really a grave one, since it prevents the voice from carrying, besides impoverishing it, must be corrected as soon as it is detected.

The horrible trembling of the voice, known as the tremolo, gives the listener the impression that the singer is trying to sing two notes and can pitch neither.

It is generally the result of over-straining, or it may be caused by training the chest register too high, forcing the head notes, a wrong method of respiration, ill-health, or nervousness.

If it is caused by over-straining, let the student practise *very softly*, not longer than a quarter of an hour at a time; if by training the chest register too high, be guided by the diagram referring to registers [page 5764], and practise all scales downwards, singing in the medium register as far as able. If by forcing the head notes, let the notes of the head register be sung *very softly* until all signs of the tremolo have disappeared.

If it is caused by a wrong method of respiration, give special attention to carry out all rules laid down for correct breath management; if through ill health, see a doctor at once; and if, lastly, through nervousness, concentrate on a thorough knowledge of exercises and songs. Slurring is dealt with later.

Fatigue of the Vocal Apparatus. Fatigue may be due to various causes, such as forcing, overwork, bad production, wrong method of study, general health, colds, tonsilar enlargement, elongated uvula, adenoids, and so on.

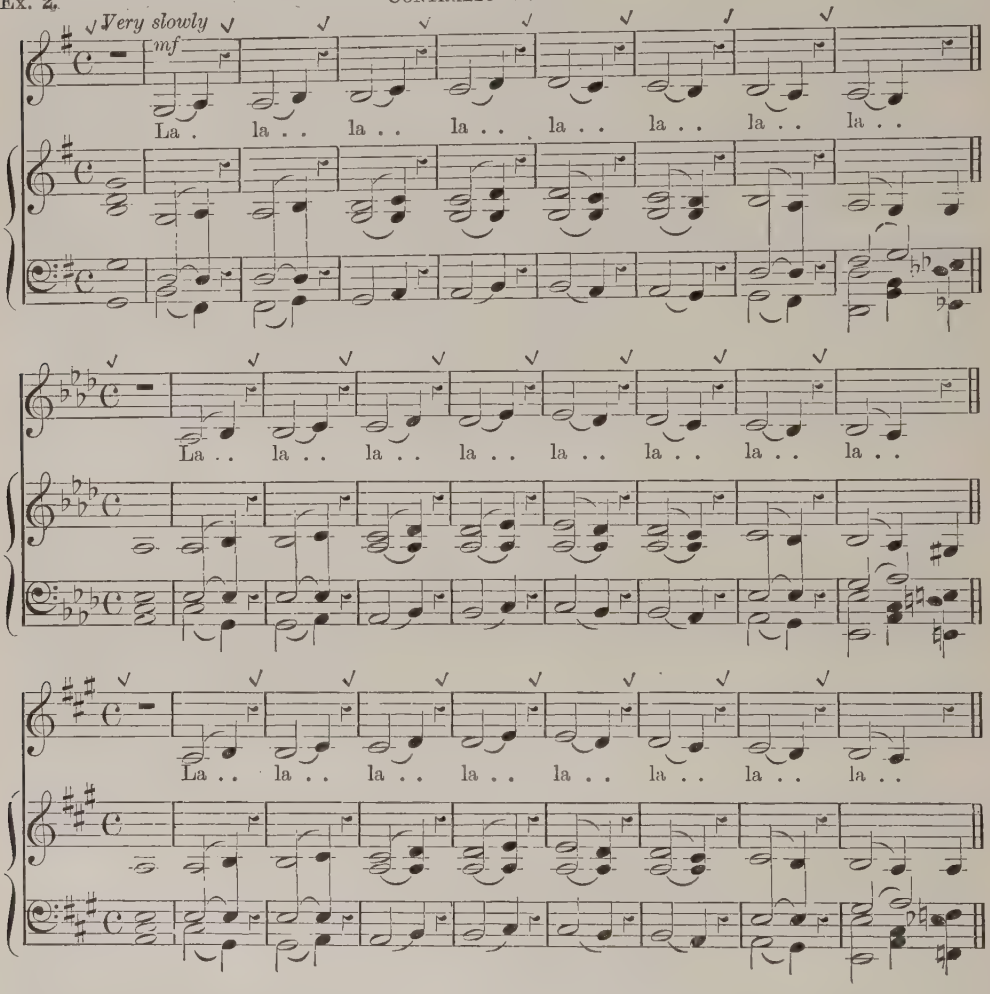
Much has already been said on the dangers of *forcing*. To overwork the voice in the hope of quickly developing it is one of the gravest faults into which a student can fall. A correct time-table for practice is given on page 5772.

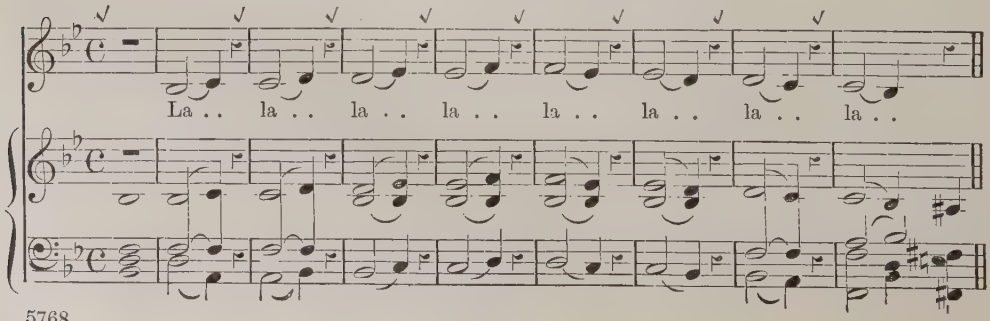
The utmost importance is attached to a correct method of study, because when a wrong method is employed, it impedes the progress of voice cultivation very considerably.

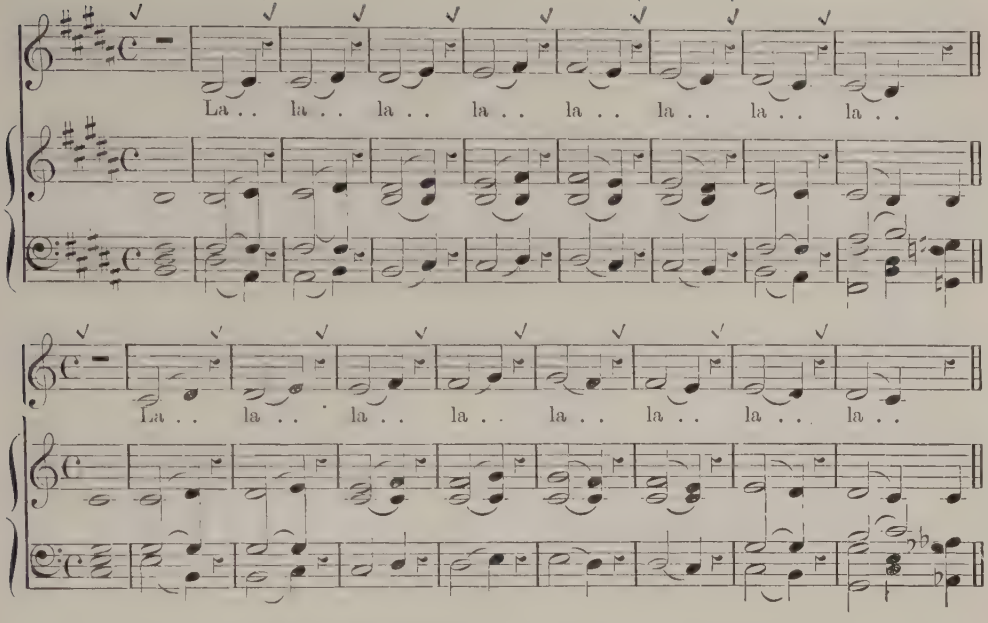
The voice is most susceptible to every degree of health; it may be regarded as the barometer of bodily health. It will be observed, therefore, how very important is a high standard of general health. The student must never practise whilst suffering from a cold or sore throat.

Forcing the Voice. Frequently, the beginner in his eagerness to possess a big voice is apt to force it—that is, he is not content to let it develop slowly and naturally but must needs strain or drive it until he has gained size, but, alas! lost the quality. This fault

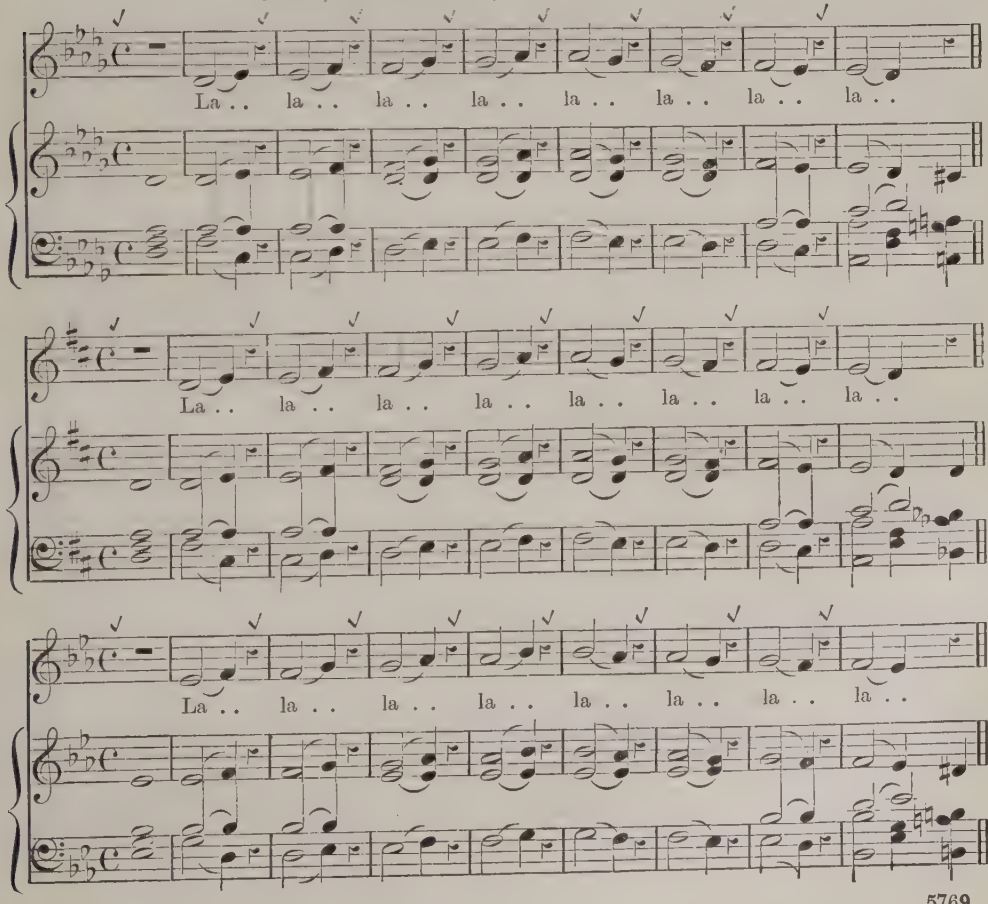
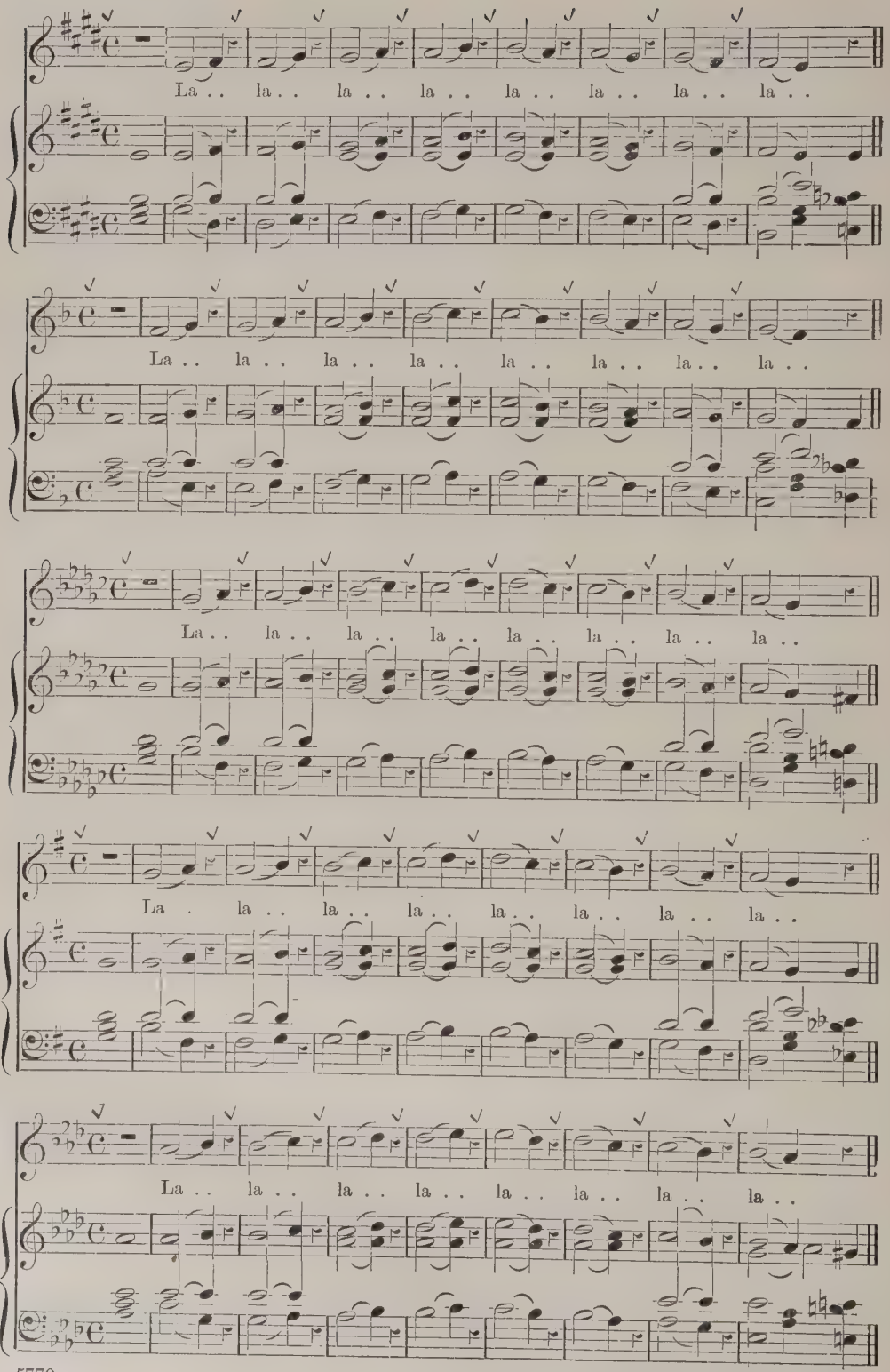
Ex. 2.

Contralto Voices.

Mezzo-soprano and Contralto Voices.



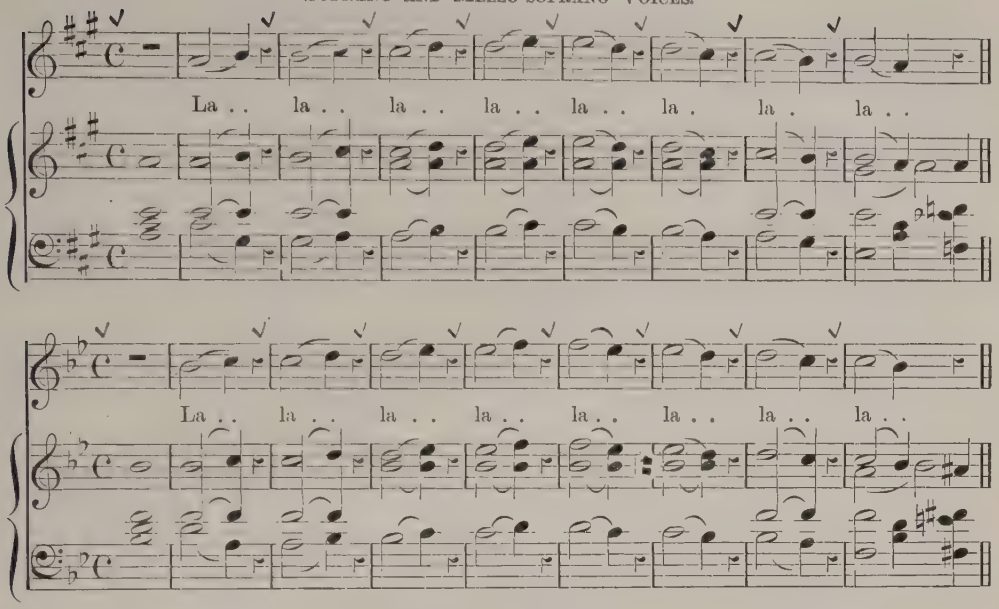


Soprano, Mezzo-soprano, and Contralto Voices.

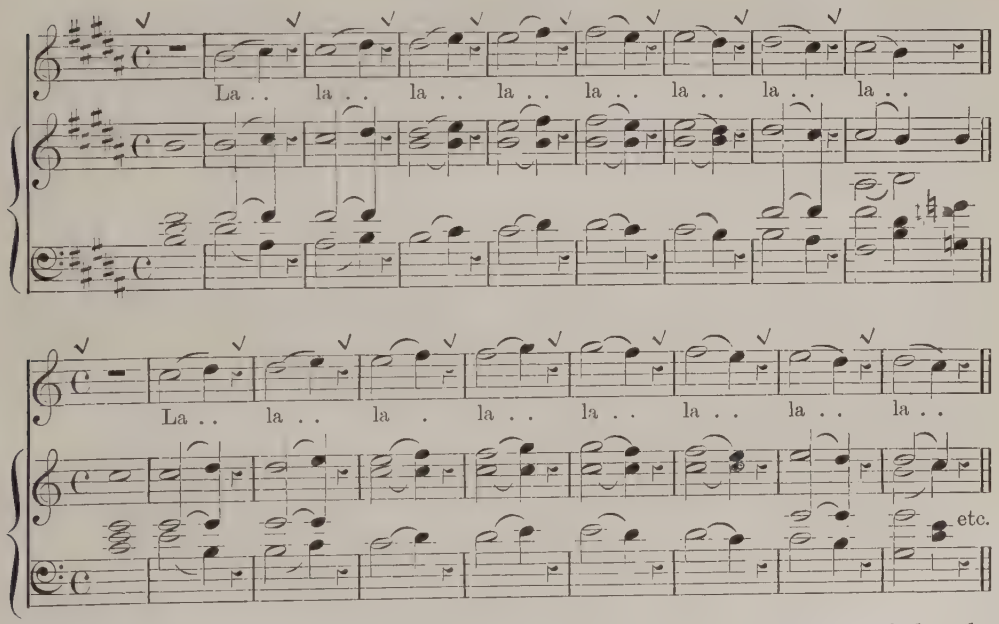


La . . la . . la . . la . . la . . la . . la . . la . .
La . . la . . la . . la . . la . . la . . la . . la . .
La . . la . . la . . la . . la . . la . . la . . la . .
La . la . . la . . la . . la . . la . . la . . la . .
La . . la . . la . . la . . la . . la . . la . . la . .

Soprano and Mezzo-soprano Voices.



Soprano Voices.



must be rigorously guarded against; if carried too far it spells ruin. Let the student who is thus inclined to force limit himself to singing *softly* until the fault is quite overcome.

The fault of tightening the throat muscles is most prevalent amongst sopranos and tenors. It is generally caused by a faulty method of respiration, and sometimes by singing with the larynx high. Let it be remembered that there must be no feeling of strain or contraction of the throat whatsoever; that a correct method of respiration must be acquired, and that the larynx, or Adam's Apple, be kept low.

Faulty Intonation. A person with faulty intonation is said to sing "out of tune," and to be either "sharp" or "flat." When "sharp" the note he means to sing is a shade higher in pitch than he intends it to be. This is caused either by tightening the throat muscles or by lack of musical ear. If the former is the case, apply the rules given for tightening the throat muscles.

If the " musical ear " is at fault, let the student strike a note on the pianoforte before attempting to sing, listen to it carefully, *mentally* aim at the pitch of the note, sing it, then strike the same note on the pianoforte again, and compare it with the note already sung.

This remedy also applies to lack of musical ear in " flat " singing. Flat singing may be attributed to ill-health, bodily and mental fatigue, lack of musical ear, but most frequently to carelessness.

High Larynx. It is utterly wrong for anyone to sing with a high larynx or voice-box. Because the larynx rises, it may be argued by some people that it is quite correct to sing with it high, but this idea must be abandoned. The larynx rises merely to let food pass more easily down the gullet, not in any way to assist in the production of tone.

Before uttering a sound, let the student open his mouth, lightly place his thumb and first finger on his larynx, or Adam's Apple, then swallow; the Adam's Apple will be found to move upwards and then downwards. When it is down it must be kept so, and in this position let the student sing a note. Let him continue practising this until able to put it into position unconsciously and naturally. When the larynx is *low*, the tone will be open, free and pure.

The Position of the Tongue. At the beginning of this course of study, the student will probably find it difficult to keep his tongue flat, and at the same time loose and free. Notwithstanding, he cannot be too assiduous in his endeavours to control it. If the student opens his mouth and tries to keep his tongue flat, he will find that in nine times out of ten it will immediately rise, either at the tip or the root.

To remedy this, let him take a hand-mirror; open his mouth rather widely, place and keep the tip of the tongue against the inside of the lower teeth, then try and draw the remainder of the tongue backwards, feeling as though the root of the tongue had disappeared. Practise without uttering a sound. Should the tongue still rise, let the student take a paper-knife and lay it along the tongue, trying to realise the sensations felt when the tongue is flat. Slowly, and without moving the tongue in the least degree, withdraw the paper-knife.

When he has repeated this exercise several times, let him again practise without the use of the paper-knife, and persevere until he is able to keep his tongue perfectly flat. On no account must he attempt to sing with the paper-knife in his mouth.

More often through carelessness and ignorance than any other cause are the soft palate and uvula allowed to " hang down " when singing, and thus impede a good production. If they are kept in this position, the tone sounds either nasal or as though it were produced through a thick curtain. The most beneficial exercise for keeping the soft palate and uvula " up " is to stand with the mouth well open, keep the tongue in position, and draw in a slow, deep breath through the mouth, directing the air towards the palate. The student will feel as though he wanted to yawn, and upon looking into his mouth he will observe that his soft palate and uvula have almost disappeared. Let him continue to practise in this way until he is able to raise them without obtaining the effect of yawning.

Mannerisms. Nothing makes a singer appear more ludicrous than facial contortions. Perhaps the most general of these contortions is the raising of one or both of the eyebrows. Other faults are undue raising of the upper lip at either corner, pushing forward the chin, inclining the head to one side, perpetual moistening of the lips, assuming a set smile, constant blinking of the eyelids, quivering of the lower lip, and a nervous twitching of the face generally. All these stupid faults can be overcome if the student will practise carefully before a mirror.

On no account must the shoulders be allowed to rise when singing; should they do so, it may be taken for granted that a wrong method of breathing is employed. As already pointed out, the shoulders should be kept down and well back, in an easy position. This is quite easy if the pupil acquires a proper method of breathing and practises before a mirror.

Another foolish mannerism, which may be easily overcome, is rising on the toes when a high note is sung. This fault is most general with tenors. If the student is inclined to raise himself on his toes, he will be wise to check it at once. Let him observe and carry out the rules for a correct position, then there will be no fear of his falling into this absurd habit.

Order and Length of Practice. The student will do well to follow out the following time-table for daily practice.

1. Long sustained notes on " La " or " Ma," slow exercises, half an hour.
2. Scales, arpeggios, and advanced exercises, half an hour.
3. Solfeggi, half an hour.
4. Songs, half an hour.

On no account must a single practice exceed half an hour.

The above table applies to advanced students only. Elementary students must never practise longer than one quarter of an hour at a single practice. If at first a fifteen minutes' practice is too long, practise ten minutes. The exact order and length of practice for elementary students will be given with each exercise.

The student should never continue practising until he feels fatigued. Sufficient time for rest should be allowed between each practice. An hour or more should elapse after a meal before attempting to sing.

Practising Hints. As regards the duration of each practice, hours of practice, and order of practice, it is of the *utmost importance* that the student should be consistent. He must have method in his work, and never be spasmodic. Unless he practises carefully, thoughtfully, and regularly, he might just as well never practise at all.

The student is well advised never to force his voice, or to shout; not to be too self-satisfied, and think he is perfect when he is only beginning;

never to practise to a pianforte that is out of tune, and never to hurry over the production of his voice.

Let him *study with his brain* more than with his voice; it is useless to practise in "parrot fashion"; he must know and think why he is singing the various exercises; keep his jaw loose and free; avoid all mannerisms; keep to simple and regular diet; and, above all, work hard and diligently, and remember that "of learning there is no end."

Singing Exercises. Alike both in male and female voices, two elements are absolutely necessary for the production of voice—the breath and tension of the vocal cords. The size and depth of the voice greatly depend upon the size and development of the larynx. As already mentioned, men's larynges are much larger than women's; that is why their voices are deeper and less acute.

Now the art of respiration has been studied, and something learnt of the various registers, the student's attention may be directed to the first singing exercises. The female voices will be taken first and then the male ones, but the following remarks apply equally to both of the sexes.

(1) Stand in the position indicated in Respiration [page 5626].

(2) Let the jaw fall naturally.

(3) When the phrase allows, inhale slowly and fully.

(4) The sign ✓ marks the place where the breath has to be inhaled.

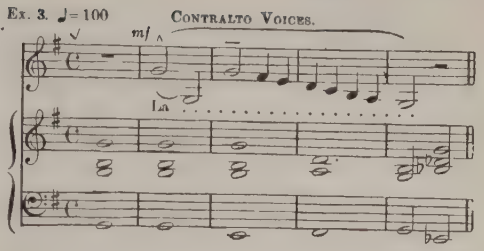
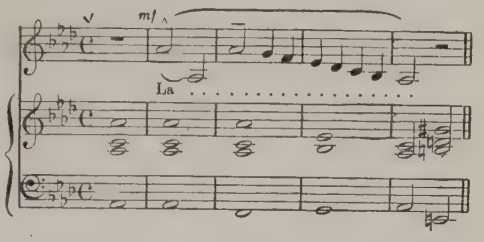
It is to be hoped that the student will, if he has not already done so, study the course on THE THEORY OF MUSIC beginning on page 88, so that he may be thoroughly conversant with the terms used in his singing exercises; for example, *mf* (*mezzo forte*) = moderately loud, *f* (*forte*) = loud, and so on. He is urged particularly to study TIME, on page 89. The student should try to realise that the more general musical knowledge he possesses the better will be the results he will obtain.

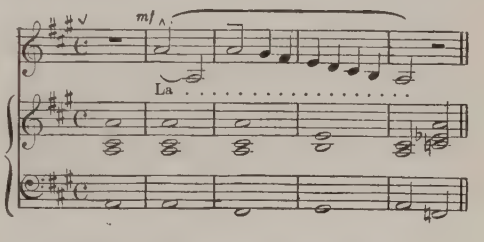
The cultivation of the female voice may begin when the student is in her eighteenth year. The male voice must not be cultivated until the student is nineteen years old.

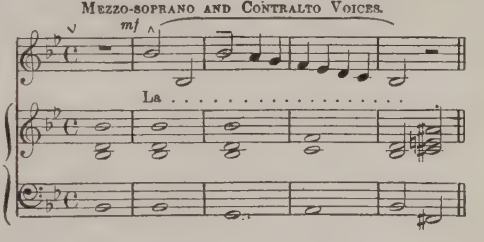
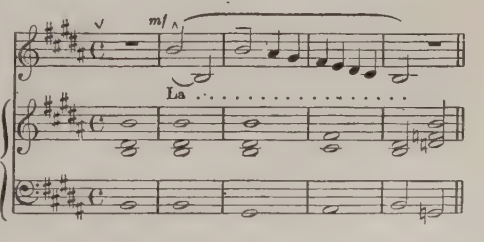
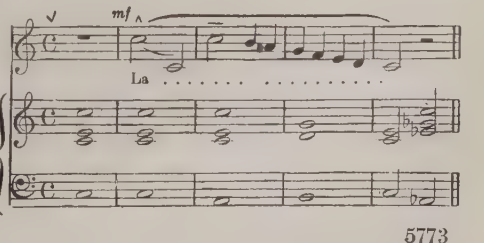
In practising the exercises **1**, **2**, and **3** in this article the mouth must be sufficiently open to admit the *width* of the thumb between the upper and lower teeth. The tongue must lie flat and naturally, with the tip touching the inside gums of the lower front teeth.

The consonants must be very distinctly articulated, and the exercises practised for several weeks—*mezzo forte*, then *forte* and *piano*—usually whilst standing before a mirror.

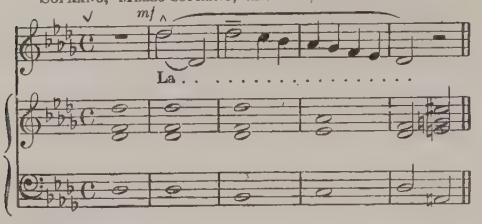
Breath must be inhaled as directed in the first exercise for inhalation, and during inhalation the note about to be sung—especially in Ex. 1—must be sounded on the pianoforte, and listened to carefully. The student must then *mentally* aim at the pitch of the note. This will help to ensure a correct intonation.

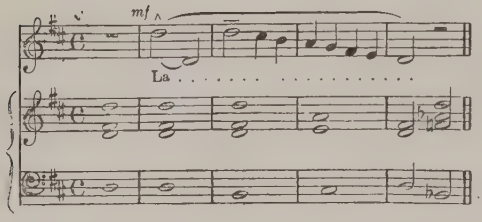
Ex. 3. ♩= 100 CONTRALTO VOICES.



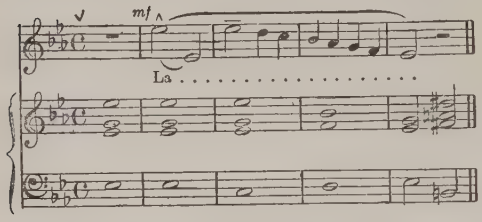


MEZZO-SOPRANO AND CONTRALTO VOICES.



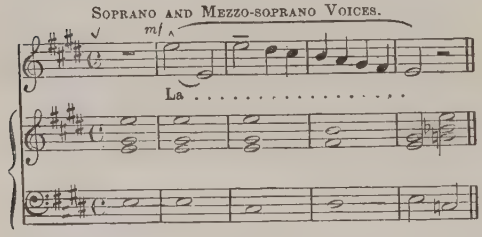
Soprano, Mezzo-soprano, and Contralto Voices.

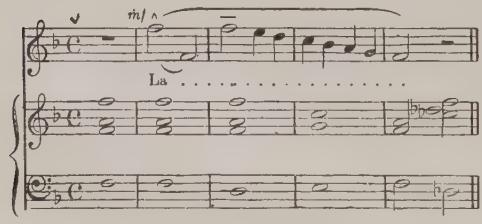




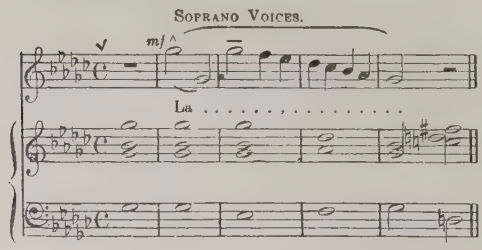


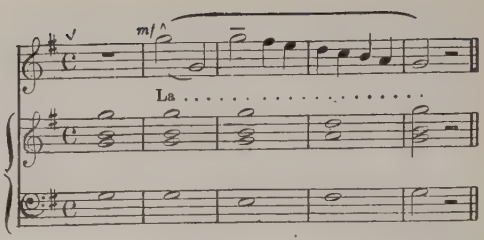
Soprano and Mezzo-soprano Voices.



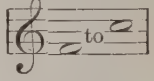


Soprano Voices.

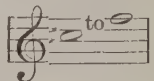




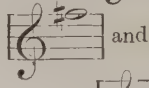
When singing the notes of

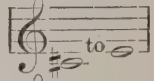
(*a*) the lower medium register— 

inclusive—the breath must be directed on to the lips ;

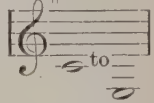
(*b*) the upper medium register— 

inclusive—to the roof of the mouth ;

(*c*) the head register—  and upwards—to the back of the head ;

(*d*) the upper chest register— 

inclusive—to the front of the mouth ;

(*e*) the lower chest register— 

inclusive—to the front of the mouth.

A Practising Time-table. The following practising table should be adhered to if the best results are to be obtained.

First and second weeks, Exs. **1**, **2**, and **3** in this article.

Third week, Ex. 3, Randegger's "Singing Primer" [page 68]. Exs. **1**, **2**, and **3** in this article also to be practised.

Fourth week, Ex. 4, Randegger's "Singing Primer" [page 79], also exercises of previous weeks.

Fifth week, Ex. 5, Randegger's "Singing Primer" [page 83], also exercises of previous weeks.

Sixth week, Ex 6, Randegger's "Singing Primer" [page 86], also exercises of previous weeks.

Seventh week, Ex. 7, Randegger's "Singing Primer" [page 89], Exs. **1**, **2**, and **3** in this article, and Concone's "Solfeggi," Ex. 1.

All voices must be kept well within their natural compass in practising, and "La"—pronounced as in the word "father"—is the best syllable on which to practise. The first song may be taken about the ninth week.

Concone's solfeggi for the different voices are these: "Soprano, Mezzo-Soprano, and Tenor Voices: Fifty Lessons for the Medium Part of the Voice." "Contralto Voices: Forty Lessons for Contralto." "Baritone and Bass Voices: Forty Lessons for Bass or Baritone." Randegger's editions of the above are recommended, because the phrasing is excellent.

Before beginning to sing a new solfeggio, the student should study it, fully realising with what object the exercise was written, whether for "placing" the voice, the legato or staccato style of singing, sustaining, phrasing, portamento, *mezza voce*, *messi di voce*, blending of the registers, or attack. As before stated, "La" is the most satisfactory syllable to use for solfeggi, and it is

sung to the first note of each phrase, *not repeated with every note.*

A student may find he produces better tones on Ma, Na, Pa, or Da, in which case he must practise on the syllable most suitable.

When he is fairly familiar with the exercises, he must practise them on the different vowel sounds—ah, a, ee, o, oo, prefixing the different consonantal powers.

Basses and contraltos are advised to omit for several weeks the exercises that are to be sung quickly.

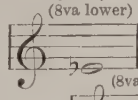
The Break. The student may find it difficult to pass smoothly, and without feeling a jerk, from one register to another. This "jerk" is most frequently noticed when passing from a lower to an upper register, especially from the chest to the medium. It is commonly called the "break."

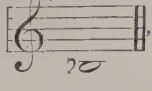
Perhaps of female voices the most troubled in this way are the contraltos. Many untrained ones have a very pronounced "break" somewhere between D (below first line, treble clef) and F (first space, treble clef). No rule can be laid down as to which note the voice must "break" upon—it depends entirely upon the nature of the voice—but on no account must the chest register in any female voice be taken above E (first line, treble clef).

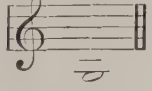
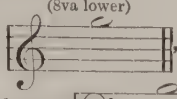
It is often possible to carry the chest register higher than this note, but however easy it may be to the student to do so, it is a very injurious practice. Besides coarsening and hardening the voice, it makes the medium and head registers very weak, and is one of the chief causes of "tremolo." The same applies to the medium register; it must never be carried up beyond F (fifth line, treble clef). Such a practice would make the "head notes" thin and shrill. The most beneficial exercises written for the "blending of registers" may be found in Randegger's "Singing Primer," pages 27–37.

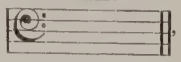
Occasionally it is advisable when singing a descending scale passage to carry the lower medium register beyond its usual limit, and so not use the chest register. When sung in this way the passage is much smoother. On *no account* must the chest register in an ascending scale be taken above its limit. If this is done, the passage is coarse and broken.

As male voices use the chest register almost entirely, they are not affected by this "break."

The above exercises recommended for female voices may be used to advantage by the male voices, tenors beginning on 

, baritones on 

, basses on

Male Voices. Male voices use the lower registers—chest and medium or "voce mista." The production of the "voce mista," or the "mixed voice," which, with tenors, begins at 

, baritones 
, basses
is very similar to the production of the upper medium register in female voices. When singing these notes "the cavity of the mouth must be completely filled with voice, which, energetically directed towards the arch of the palate, will rebound from it, rendering the sound full and sonorous" (Randegger).

The three exercises already given for female voices are recommended for male voices, and are to be practised in the same order, 1, 2, and 3; but instead of beginning on F (first space, treble clef), the tenor must begin with E flat (first line, treble clef), and practise to G (above treble clef); the baritone with B flat (immediately below middle C), and practise to E flat (fourth space, treble clef); the bass with G (fourth space, bass clef), and practise to C (third space, treble clef). It must be borne in mind that the notes actually sung by the male voices are an *octave lower* than those indicated by the treble clef.

As the voice develops the compass may be extended, either upwards or downwards, or in both directions, as is natural to the voice. The student is advised to limit his compass for several weeks. The directions given for female voices apply equally to male voices.

When singing the notes of the chest registers the throat must be kept well open, the larynx low, and the breath directed *on to the lips.* To produce the "mixed voice" correctly the mouth must be more open than for the chest voice, the tongue lie quite flat, and the breath directed *to the roof of the mouth.*

Signor Randegger says: "Every student of singing should pay particular attention to the various physical sensations experienced in producing the tones of the different registers."

The vibrations of the notes of the different registers are felt:

(*a*) Lower chest, in the lowest part of the chest.

(*b*) Upper chest, in the upper part of the chest.

(*c*) Lower medium, in the lower part of the mouth.

(*d*) Upper medium and "mixed voice," in the front part of the face and towards the forehead.

(*e*) Head, in the back part of the head.

MARY WILSON

A Short Dictionary of Terms in Music appears on page 1823 of the Self-Educator

Steamers and Smacks. Methods of Capture. Nets and Lines. Motor Fishing Craft. Migration of Fish. Hatching. Diseases. Preservation. Markets. Fishing Law.

BRITISH FISHERIES

FEW people—even those who are engaged in one or other of its numerous branches—have any adequate idea of the enormous proportions of the British fishing industry. The not infrequent reports of casualties to fishing vessels which are met with in the columns of the daily Press furnish the reader with some idea of the dangers incidental to a calling at all times difficult and hazardous, success in which is only granted to the hardy, the active and bold, and mistakes in which result too often in a speedy death.

Vast Extent of British Fisheries. Before the outbreak of the European war there were over 16,000 sea-going vessels engaged in fishing from the various ports in the British Isles. These vessels are manned by not less than 100,000 fishermen, and in the course of twelve months they land nearly 1,233,000 tons of fish, worth to the fishermen about £14,300,000. By the time this fish has reached the consumer its value will be considerably enhanced, the exact amount paid by the consumer being probably not less than £100,000 per day. The value of the ten most important fishes in the year 1913 is appended:

Herring	£4,572,295
Cod	2,300,119
Haddock	1,891,005
Plaice	1,095,394
Hake	678,981
Soles	474,127
Halibut	460,722
Whiting	390,981
Turbot	302,411
Skates and rays	292,962

For the purpose of fishery statistics a distinction is drawn between *wet* fish and *shell* fish, the former being fishes proper, the latter including oysters, mussels, cockles, crabs, shrimps, and lobsters.

Trawling. Of the various methods of capture in vogue at the present day, undoubtedly the most important is trawling. Trawling is carried on from both steam and sailing vessels, the latter being divided into two classes—the first class consisting of vessels of upwards of 15 tons [1], the second class of vessels below that tonnage. The most remarkable feature in the rise of the trawling industry is the rapid growth both in numbers and in size of the steam trawler, and the consequent supplanting of the smack. In 1913 there were 1359 steam trawlers, 16 motor and 805 sailing trawlers of the first class engaged in fishing from ports in England and Wales.

Steamer versus Smack. The slow method of the cutter is rapidly giving way to the scientific methods of the steam trawler [2]. But since the tendency of modern legislation is to exclude the steam trawler more and more from the inshore waters, there always will be room for the inshore fisherman, who, however, in order to be able to compete in the market with his wealthier and more powerful rival, will have to adopt newer methods. Already on the Continent fishing boats which formerly relied on the wind for their propulsion are being extensively fitted up with motors; and the attention of the English smacksman is earnestly directed to the advisability of inquiring into the advantages of the various internal-combustion engines now on the market.

Trawl Nets. Modern trawl nets are of two main types, the *beam trawl* and the *otter trawl*, the former being almost exclusively used in sailing vessels, the latter in steamers. Both nets are constructed and fished with the same object—they sweep along the ground, and consequently are only adapted for catching those fish which live on or near the bottom. Such fish as soles, dabs, plaice, haddock, and cod are captured by this method of fishing, other methods being employed for herring, mackerel, and similar species which live near the surface. The net attached to the *beam*—which consists of wood, and averages from 20 to 50 ft. in length, according to the size of the vessel using it—is shaped somewhat like a flattened cone [4]. The beam is affixed at each end to a triangular iron frame—the *trawl head*—these frames being dragged along the bottom with the beam attached to the apex of the triangle so that when in action the beam is raised a few feet above the ground and forms the upper boundary of the mouth of the trawl [3]. The lower margin of the trawl mouth consists of a heavy rope, the *foot-rope*, considerably longer than the beam, so that it curves backwards behind the beam, and, unlike it, is in contact with the ground. The terminal portion of the net is known as the *cod-end*, and is fastened by a rope which can be detached when the trawl is hoisted on deck, the catch being thus easily liberated. At intervals in the net there are net-like contrivances known as *pockets*, which, in effect, minimise the efforts of fish to escape through the mouth of the net. The trawl is towed along by two ropes, the *bridles*, which are attached to the trawl-heads, and united at the *shackle* to form a single towing rope —the *trawl-warp*.

Improvement of the Trawl. About the year 1893 a modification of the trawl was introduced [5], and this may briefly be described as a supersession of the *beam* by means of a rope called the *head-line*, the main advantages being a greater length of opening, head-lines of over a hundred feet in length being common. At either end of the *foot-rope* is attached a heavy wooden door-like board, the *otter-board*, and to these boards the *trawl-ropes* are attached in such a manner that the former are dragged along the bottom on one of their long edges, the surface of the board being inclined at an angle to the direction in which the net is being dragged, so that the mouth of the net is kept open. There are two warps used with the otter-trawl, instead of one only as in the beam-trawl. When the trawl is shot and on the bottom, the steamer tows it along slowly, a fair average speed being about three miles an hour. The pressure of water is exercised in such a manner that the boards are forced upwards and apart, the mouth of the net being thus kept in a distended position. The *head-line*, which is a few feet from the bottom, passes over the fish before they are disturbed by

the *foot-rope*, which curves backwards as described above. The fish when disturbed swim upwards and strike the netting of the upper part of the net, which is now well above them, and the pressure of the water forces them into the net towards the *cod-end*. The lower part of the net, which runs along the bottom, is subject to considerable wear and tear, and is strengthened by apron-like pieces of netting, which save the net proper.

The Seine. Intermediate between the *trawl* and the *drift-net* described below is the *seine*, which resembles the trawl in its being dragged through the water, and the drift-net in that it is a vertical wall of netting. It is almost exclusively employed in inshore fishing, and for such fish as herring, mackerel, pilchards, bass, and mullet. The seine consists of a vertical wall of netting, to the upper part of which corks or *floats* are attached; to the lower part, weights or *sinkers*. It is used from two boats, or from the shore with one boat. In either case the net is piled up in the stern of the boat which moves. In this way an area is surrounded by the net, which is pulled in gradually towards the shore.

1. FIRST-CLASS DEEP-SEA SAILING TRAWLER
(The beam trawl is on deck)

Drift Netting. While *trawling* and *lining* are the methods employed for the capture of bottom-living fish, for those fish which live in intermediate depths to the surface other methods have to be used. Such a method is the *drift-net*, extensively practised in the capture of herring, mackerel, and pilchards. A drift-net carried by a Scottish sailing boat ("Fifie") of the largest class usually amounts to 42,000 square yards, and consists of 70 nets, each of an area of 600 square yards. This *fleet* of nets extends to 2590 yards. The whole net hangs vertically in the water, forming a wall of network against which the fish impinge. The upper surface of the net is attached to a rope supported by cork floats, the whole apparatus being so arranged that it can be fished at any required depth, and when fishing it drifts with the tide. Nets of different-sized mesh are used according to the fish which it is desired to capture, the usual size for mackerel being 1¼ in. from knot to knot, for herring 1 in., and for pilchards ¾ in. When a fish strikes against the net its head passes through, but owing to the increasing size of its body the fish is fixed in the mesh. Even in this method of fishing we find steamers extensively employed. In 1913 there were 864 steam drifters engaged in Scotland, where the sail drifter is rapidly disappearing.

2. FLEETWOOD STEAM TRAWLER

Drift nets were originally made of hemp in Ireland, and in the Isle of Man of flax, but at the present day they are chiefly made of cotton, the greater lightness of which has enabled fishermen to extend the length of their nets. The introduction of an auxiliary engine for hauling has also enabled fishermen to extend the length of the nets.

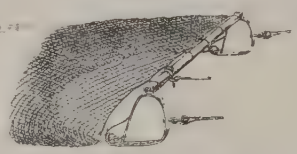
The Trammel Net. Except for the fact that it is fixed, the *trammel* might well be regarded as an offshoot of the drift-net. It consists of three vertical nets fastened together at the top, bottom, and ends. The middle net *hangs loose*, and is of small mesh. The outer nets, one on either surface, have wide meshes, from three to six inches or more from knot to knot, and are of coarser thread than the inner net. The fish swims along until it strikes the outer net; then it darts forward suddenly, pushes against the central net, and carries a portion of it through the large meshed net on the other side. The fish is then safely trapped in a sort of pocket, or, technically, is *trammelled*.

The Stake Net. The *stake net* is a vertical wall of netting supported by stakes, and is a fixed apparatus employed in estuaries. It is a very ancient method of fishing, and a very destructive one; consequently its use is restricted as far as possible. As a general rule, these nets may not now be set right across a stream or channel, and there are other regulations, which vary in different localities, as to the size of mesh and the total length of the net. The varieties of stake net are legion, but it is in the United States that they have reached their maximum development. In this country the nets are usually a simple wall with or without a trap-like arrangement at the fishing end. They are set at right angles to the direction of the tide, and may be calculated at certain seasons of the year to yield the maximum of result with the minimum of effort.

Line Fishing. A large quantity of deep-sea fish is still caught by *lining*, and this is more particularly the case in Scotland, where, in 1913, twenty steamers were exclusively engaged in this method of fishing. Twenty per cent. of the total quantity of demersal fish landed in Scotland is caught by liners. A line as used on a steam vessel is usually several miles in length, and at intervals of about 6 ft. is provided with pieces of line, the *snoods*, to which baited hooks are attached. The position of the line is marked by buoys. The hooks are usually baited with mussels, whelks, or herring, and the lines are shot in the evening, and fished in the morning. The line can be used on rocky ground where trawling is obviously impossible.

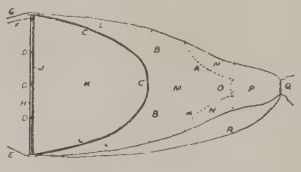
Fishing for Crustacea. In addition to the various methods of fishing for *wet* fish, which have been described, there is an extensive fishery for various crustacea, such as shrimps, prawns, lobsters, and crabs, the value of which to the fishermen of the British Isles is certainly not less

than £460,000 a year. Shrimps are fished for by *trawl nets*, and also by *hand nets*. The former are modifications of the beam trawl adapted for catching shrimps, the *mesh* being three-eighths of an inch from knot to knot, and the beam not more than 25 ft. in length. The *shank net* is very similar, the mouth of the net being, however, kept open by means of an oblong frame of iron or wood. This net is used precisely like a trawl, being dragged along the bottom, and while so dragged the frame is kept in a vertical position, the longer axis being horizontal. Such nets are frequently used from carts which are driven along in a few inches of water at low tide. In similar localities, a hand net, known as a *push* or *power net*, is used. This varies in different parts of the coast; generally speaking, it consists of a triangular net attached to a framework, the whole apparatus being fixed at the end of a long pole. This net is pushed in front of the shrimper in shallow water, at low tide, and is hence locally known as a *shove net*. On his back the shrimper carries a large basket for the reception of his shrimps. Crabs and lobsters are mainly fished for by baited pots, in reality basket-like arrangements, or traps, which afford facilities for the ingress but bar the egress of the crustacean. These pots and baskets are lowered to the bottom, often in fairly deep water on rocky ground, their position being indicated by buoys. At the end of several hours the fishermen revisit the grounds, examine the pots, remove the lobsters or crabs that have been caught, and finally rebait their pots with stinking fish.



3. TRAWL HEADS, ILLUSTRATING BEAM AND MOUTH OF NET
Showing how the bridles are attached

Fishing in the Future. A remarkable change has taken place in the fishing industry during the last thirty years. Previous to the advent of the steam fishing boat the smaller fishing villages were relatively far more important than they are at the present time, and the inshore fisherman who followed different classes of fishing at different seasons of the year—trawling, drift-netting, lining, and shrimping—is fast being replaced by the steam fisherman, who is a specialist pure and simple.



4. DIAGRAM OF BEAM TRAWL
a. Where the net is sewn together to form pockets *b*. Where the square joins the baitings *c*. Foot-rope *d*. Grommets *e*. Forward bridle *f*. Dandy bridle *g*. After bridle *h*. Beam *j*. Head-line *k*. Square of net *l*. Wings *m*. Baiting on top, belly underneath *n*. Pocket *o*. Flapper *p*. Cod end *q*. Poke-line *r*. Cod-line

The bulk of the sea fish is landed at half a dozen large ports, such as Grimsby, Hull, Aberdeen, Yarmouth, Lowestoft, Fleetwood, and Liverpool, where access to the quays and wharves is available at all stages of the tide. The fish landed is usually sold at once by auction, and then forwarded to the markets at the large inland towns. The sailing smack owned partly or entirely by the man who sailed her is slowly but surely decreasing in numbers, and is being supplanted by the steamer, owned almost invariably by persons whose interest in the fisheries is mainly dependent upon their dividends. The fishermen are paid servants, or in some instances are paid by a share of the gross profits, the skipper and mate usually being paid by shares, the rest of the crew by a weekly wage. Already there are whispers of "rings" of buyers and dealers in fish; and who can say what the future of the inshore fisherman is to be?

Conditions of Success in the Future. The self-reliant and independent fisherman will therefore take heed of the future: only by embracing as far as may be practicable newer methods of fishing will he be able to compete successfully with his formidable rivals. The adoption of means of keeping his catch in good condition, and for securing its rapid transit to the market, the introduction of labour-saving devices for manipulating his gear, and, above all, the question of auxiliary propulsive methods to assist the uncertain winds, are all subjects which will imperatively demand his immediate and earnest attention.

Quite recently a society, called the Fisheries Organisation Society, of Queen Anne's Chambers, Westminster, has been formed to assist the inshore fishermen. The society does no trading itself, and makes no profit. It fosters co-operation among the fishermen, and forms local fishermen's co-operative societies for the better marketing of fish, the co-operative purchase, hire, and insurance of boats and gear, and for other matters connected with the welfare of the inshore fishermen. The society seems to have been formed on right lines; and it is to be hoped that its efforts to improve the condition of the inshore fishermen will meet with success.

Motor Fishing Craft. The possibility of the application of motor power to the sea-fishing industry has for some time been recognised, notably in Denmark, Scandinavia, and in the United States, and auxiliary internal-combustion engines have been applied to various classes of fishing smacks, and especially to deep-sea cutters of similar build, to the first-class English sailing trawler, to herring and to open line-fishing boats. This application must at present be regarded as having passed the experimental stage.

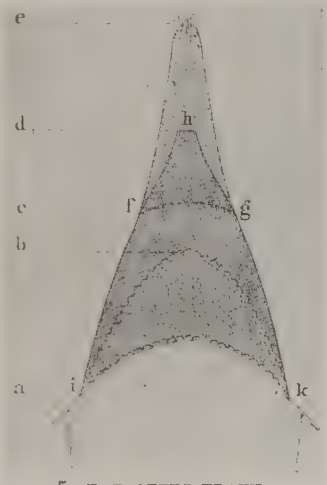
This must not be taken to mean that any sort of motor will do for a fishing boat. The problem is not quite so simple as that. The chief point to consider is whether the motor is required for propulsion only as in line-fishing, lobster and crab boats; or whether in addition to this main purpose the motor will be required, as in a sailing trawler, for trawling and hauling in the gear. In cases where the motor serves exclusively, or almost exclusively, for propulsion, it has already proved a success. In Scotland, where sailing trawling does not exist, and where the sailboats follow herring drifting and line-fishing, there was in 1901 only one motor boat taking part in the Scottish fisheries. In 1913 there were 523 so engaged. Of these, 182 were first-class boats (over 30 ft. keel), 313 second-class (18 to 30 ft. keel), and 28 were third-class boats (under 18 ft. keel). In England and Wales, where the sailing trawler predominates among sailing boats the progress is not nearly so rapid. In many instances motors have been installed in sailing trawlers by engineers unacquainted with the details of trawling; and although the motors have been serviceable for journeying to and fro from the fishing grounds, they have been a failure or only of very moderate success in trawling.

In the case of a trawler propelled otherwise than by sails—for example, a steam trawler [**6, 7, 8**]—when the vessel is fishing the trawl-warps lead

astern. In a sailing trawler when at work, the trawl-warp leads off the quarter, or even at right angles to the vessel's side, the skipper taking full advantage of wind and tide, and under such circumstances not much use can be made of the motor. Motors are not very popular at present among trawlers; and of the 153 motors installed in first-class English sailing vessels, only six are in vessels exclusively engaged in trawling. Of the 194 second-class vessels similarly equipped, 14 are exclusively trawlers.

Fishing Boat Motors. Motor engineers are now fully awake to the immense field for enterprise in the fishing industry, and there are a large number of British-made engines specially built for fishing boats. These engines run on petrol, paraffin, or crude oil. Among the leading makes of British engines are the Gardner, Kelvin, Thornycroft, Beardmore, Blackstone, Griffin, Parsons, Gleniffer, Grampian, and others. The Gardner, Thornycroft, Blackstone, and Griffin are paraffin engines on the four-cycle, and the Beardmore a paraffin engine on the two-cycle, principle. The Blackstone and Griffin work on the cheapest crude oil. In some districts of Scotland such as the Orkney Islands the fishermen instal second-hand motor-car engines in their boats. The horse-power of the engines installed in fishing boats ranges usually from 4 to 90 h.p., but is in the majority of cases below 10 h.p. Prices vary considerably, but as a rule an engine developing about seven-horse power can be obtained for between £65 and £90. A serviceable 13 to 15 horse-power engine ranges from £105 to £150, reversing gear being extra in each case.

The type of motor with detachable propellor [**9** and **10**] has not been adopted in the British Isles, but the type is represented in the case of small open fishing boats by a detachable motor of the Evinrude class.



5. THE OTTER-TRAWL

Between *i* and *k* (the otter boards) stretch above the head-line and below the ground-rope. The head-line is the shorter. The foot-rope curves backwards (*a-b*). *i-b*, *k-b* are the wings, *c-b* the belly, *f-g-h* the trap or pocket, and *e-d* the cod-end

Science and Sea Fishing. Of late years much attention has been given to the application of biological and hydrographical investigation to the elucidation of problems connected with the sea fisheries. Schools of "fishery science" have been established, notably at Bergen. Marine stations have been erected and equipped with the latest and most up-to-date apparatus for the study of applied marine biology; and practically every European country with a sea coast has one or more biological stations.

Institutions for the *hatching* of sea-fish have been erected on the coasts of Northern Europe and America, in England at Piel and Port Erin, and in Scotland at Aberdeen.

An International Council. Since 1902 an international council of scientific men has been engaged in the study of the causes that affect the harvest of the seas, and an enormous sum of money has been expended on fisheries investigation. The central laboratory is established at Christiania, and the office or bureau is at Copenhagen. Each country has, in addition, its own laboratories, steamers, and a trained staff of naturalists, hydrographers, chemists, and physicists, all working to a common end. Voluminous reports appear from time to time; and as the results to be obtained may have an important bearing on the fisheries, especially with reference to future legislation, it is well for the intelligent fisherman to learn something of the methods employed by expert scientific men, and the results which have up to the present been obtained.

Considerable attention is now being devoted to the *physical* as distinguished from the *biological* conditions which obtain in our seas. The methods of observation which were first of all practised by the famous "Challenger" expedition are being now amplified and applied to the determination of those changes in the physical condition of the seas which may reasonably be supposed to affect the presence of fish, and consequently the success or otherwise of the fisheries.

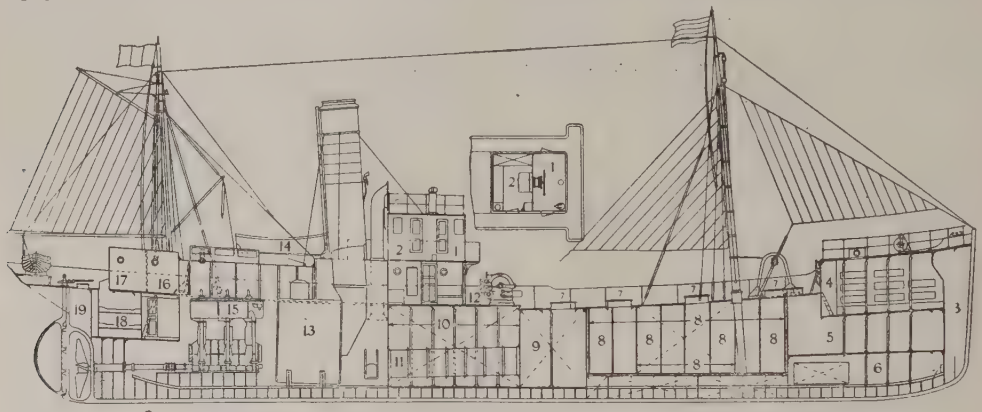
Physical Character of Sea Water. The characters of sea-water (apart from the plankton, which is separately considered) that are investigated are the *temperature*, *salinity*, *density*, and *gaseous contents*. By means of the first three data it is possible to trace the movements of large bodies of salt water, and to determine at given seasons of the year whence the water in our seas—the North Sea, English Channel, and Irish Sea, for instance—is derived. The movements of shoals of fish, such as the herring and anchovy, may possibly be correlated with the movements of bodies of water of a certain temperature and density. It is claimed that the anchovy fishing in the Scheldt is closely connected with the temperature of the sea, and that the arrival of the autumn herring off the Norwegian coast corresponds with the appearance of water of high temperature and medium salinity. At present these observations are carried out on the special steamers which are subsidised by the various Governments.

How the Sea is Analysed. The methods are briefly as follows: Soundings are taken to determine the depth and nature of the bottom; observations of temperature are made at the surface and at varying depths. Samples of the floating organisms are collected at the surface and at various depths. The temperature, pressure, and humidity of the atmosphere are also noted. Samples of water are also collected for analysis. The results are then collected and deductions drawn at the shore laboratories. Charts are published showing the lines of equal temperature (*isotherms*) and lines of equal salinity (*isosalines*).

It has been found that the waters in the English Channel are derived in February and May from the Bay of Biscay, in August from the Irish Sea, and in November from both sources. North Sea water is derived from three main sources: (*a*) North Atlantic water of high density enters chiefly from the north-west; (*b*) Baltic water of low density enters as a surface current from the Skagerack; and (*c*) North Sea water of medium salinity. There is also what is known as Bank water forming a fringe to the coast line. It consists of a mixture of Atlantic and

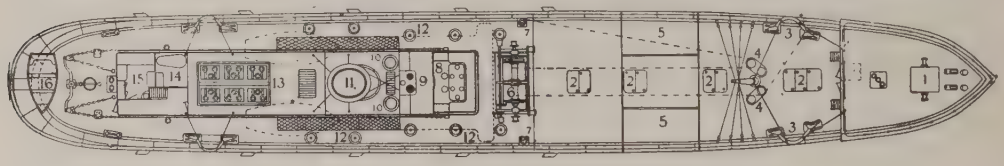
Baltic waters. There are various seasonal changes in the inflowing and outflowing currents, which prove that the North Sea fishing grounds are subject to periodical variations with respect to the water covering them. The ultimate bearing of these hydrographical observations on sea fishery problems is for the future to decide. They are still being carried on, and it would be premature to criticise the results until further information is at hand.

Drift Bottles and Surface Currents. The determination of the influences which affect the distribution of floating bodies has been largely accomplished by means of *drift bottles*: means of cork covered with paraffin-wax, a special voyage is made on a scientific steamer, and the bottles are thrown out at intervals of five minutes or so along certain lines which have been previously selected as likely to furnish important results. The rate at which the steamer travels being known, the distances at which the bottles are dropped overboard can be marked off on a chart. As the postcards return to the laboratory, the journeys made by the bottles can be traced. Some of the bottles are picked up very soon, others perform remarkable journeys. The effect of tidal currents and the wind on the distribution of surface organ-



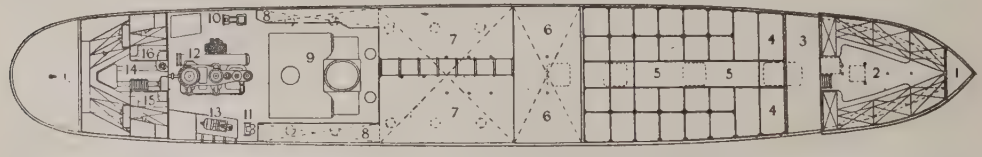
6. LONGITUDINAL SECTION AND BRIDGE-PLAN OF A STEAM TRAWLER

1. Wheelhouse **2.** Captain's cabin **3.** Collision bulkhead **4.** Crew's quarters **5.** Store-room **6.** Chain locker **7.** Hatches **8.** Fish-hold **9.** Cross bunker **10.** Main bunker **11.** Gangway **12.** Steam winch (for trawling) **13.** Stokehold **14.** Lifeboat **15.** Triple expansion engines **16.** Bathroom **17.** Mate's quarters **18.** Dining-room and engineers' quarters **19.** Store-room



7. DECK-PLAN OF A STEAM TRAWLER

1. Winch (for anchor) **2.** Hatches **3.** Gallows **4.** Bollards **5.** Fishpounds **6.** Steam Winch (for trawling) **7.** Bollard **8.** Officers' messroom **9.** Galley **10.** Ventilators **11.** Funnel **12.** Entrance to bunker **13.** Engine-room skylight **14.** Bathroom **15.** Mate's cabin **16.** Boat



8. BELOW-DECK PLAN OF A STEAM TRAWLER

1. Collision bulkhead **2.** Crew's quarters **3.** Store-room **4.** Ice-hold **5.** Fish-hold **6.** Cross bunker **7.** Main bunker **8.** Side bunkers **9.** Stokehold **10.** Pump **11.** Auxiliary pump **12.** Engines **13.** Dynamo **14.** Dining-room **15, 16.** First and second engineers' cabins

Strong, short-necked bottles are weighted with a small quantity of sand, so that they are immersed with as little of the neck protruding as possible. Each bottle has enclosed in it a stamped postcard addressed to the laboratory from which the experiments are initiated. The postcard has a printed statement on it requesting the finder to fill in information as to the date and place of finding, and to post the card. It is found that in a somewhat circumscribed area, such as the Irish Sea, about one in every three bottles is picked up, and the postcards returned with the requisite information. A number of bottles being weighted and made watertight by isms is in this manner estimated, and the problem has a practical bearing, as will be seen later, in determining the most favourable locality for the *planting* of the fry from marine hatcheries.

The Plankton Investigations A word that is frequently used in all discussions on sea fishery matters is *plankton*. All organisms which merely drift and are consequently at the mercy of the wind and tide are included in the plankton, in contradistinction to those animals which, like fish, are capable of independent motion, and are therefore able to move against a tide or current. The *plankton* has been studied for a number of years,

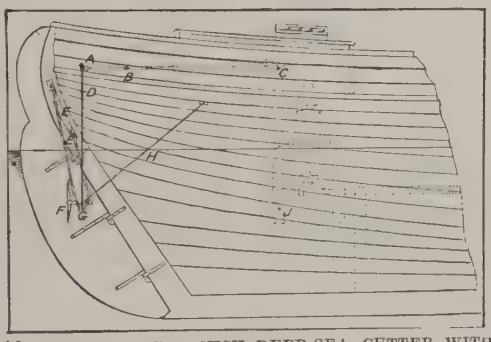
and its constitution is fairly accurately known. It consists of minute plants, such as diatoms; various animalcules, small crustacea, especially those known as *copepoda*, the larvæ of free-swimming young stages of various worms, crustacea (crabs and lobsters), mussels, cockles, oysters, and other shellfish: and the floating eggs and larvæ of most of our food fish, the only notable exception being the herring, the eggs of which sink to the bottom, and develop there.

Now, the plankton, apart from interesting facts which are discussed later, is of considerable importance, insomuch as it serves as a direct source of food supply of some of our most valuable fish, notably the herring, pilchard, sprat, anchovy, mackerel, and others. There can be no reasonable doubt that the supply of these important fishes bears a direct relation to the amount of plankton present in the ocean.

Collection of Plankton. The plankton is collected by means of fine-meshed nets of silk bolting cloth, which are known as *tow nets*, having for their object the fishing out of plankton from a definite volume of sea-water. Of these nets the most successful is the vertical plankton net invented by Hensen [11]. This net, which is shaped like an inverted truncated cone, is lowered perpendicularly in the water to a given depth, and then raised to the surface, also perpendicularly. By this method a cylindrical column of water filters through the net, and its planktonic constituents are captured.

9. DANISH DEEP-SEA CUTTER WITH MOTOR AND LOOSELY SUSPENDED PROPELLER

The Quantitative Examination of Plankton. The volume of this cylindrical column of water can be estimated, since the filtration capacity of the net can be calculated, and the depth to which the net is sunk is known, as is also the area of the net opening. This being known, the number of organisms captured in the column of water through which the net has fished can be ascertained, and thus the contents of a given volume of sea water are known. The catch is next preserved in some suitable medium, such as *formalin* or *spirits*, and then it is subsequently estimated in the laboratory. There are four chief methods of estimating the contents of the catch—by *volume*, by *weight*, by *chemical analysis*, and by *enumeration*. For the latter, a special form of microscope is used, having a large mechanical stage, which by means of two screws can be rotated in any given direction. The stage is ruled with fine lines cut by means of a diamond, and these lines divide the stage into squares. Consequently, it is a simple though tedious matter to enumerate the constituents of a given column of plankton.



10. DIAGRAM OF DANISH DEEP-SEA CUTTER WITH SUSPENDED PROPELLER

a. Toothed wheel *b.* Shaft *c.* Pulley *d.* Endless chain *e.* Movable iron bars *f.* Propeller *g.* Screw-axle *h.* Removable iron rod *j.* Driving wheel

Important results have been deduced from this method of enumeration, more especially with regard to the floating fish-eggs. Take, for instance, the Eckenförde fishery in the West Baltic. This fishery for cod and plaice is carried on over an area of about 16 sq. miles, and there are on an average in January, 30; in February, from 45 to 50; in March, at least 60; and in April, 50 floating eggs of cod and plaice for every square metre of surface (a square metre equals 1·196 sq. yd.). These eggs take on the average about fifteen days to develop under the conditions which obtain in the West Baltic, so that the numbers above recorded must be doubled in order to give the number occurring per month under the square metre of surface water. This gives 370 eggs from January to April.

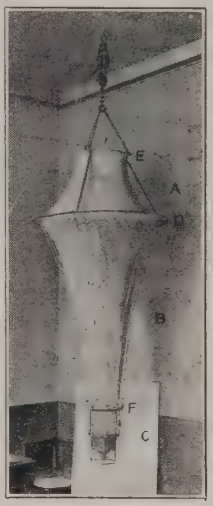
Determination of Intensity of Fishing. Now, it has been calculated from a nine-year average that the number of cod and plaice annually caught by the fishermen of this district would, if allowed to remain in the sea, have produced 110·5 eggs per square metre of surface water. This, added to the 370 above, gives a total of 480·6, which represents the number of eggs that would have been produced from all cod and plaice, captured and free yearly for each square metre of surface water. As a consequence, $\frac{110{\cdot}6}{480{\cdot}6} = \frac{1}{4{\cdot}4}$ gives the fraction of the total quantity of adult cod and plaice actually captured, or, in other words, man captures for his own consumption about one-fourth of the total number of adult fish in this locality in the West Baltic. This estimation has been confirmed in a remarkable manner by the marked-fish experiments which are now being carried on in the North and Irish Seas.

Marked Fish Experiments. Plaice are marked [12] with a numbered brass label attached to their bodies by a silver wire and then liberated. The active co-operation the fishermen is secured by means of a system of payment of rewards for marked fish returned to the laboratory, with information as to date and place of capture. A large number of such fish marked have been returned to the laboratories at Lowestoft and Liverpool, and it has been calculated that trawl fishing in the southern part of the North Sea has caused an appreciable reduction in the numbers of the larger plaice of 10 in. in length and upwards, this reduction amounting to from 20 to 30 per cent. of the total population of this size in one year. This corresponds very closely with the estimate of 25 per

cent. derived years ago by the study of the plankton along quantitative lines.

Other results from fish-marking experiments may be briefly mentioned here. The extent and nature of the migration of plaice is one of the chief results to be noted. In the southern part of the North Sea, plaice migrate from the inshore to the offshore grounds, in spring and summer months the general direction being a northerly one. Larger fish move quicker and farther than smaller ones. It is perhaps rather dangerous to attempt generalisations of too broad a nature, based as they are at present on rather insufficient evidence, but there seems to be a winter migration of all plaice above 9 in. in length towards the south.

Practical Bearings of Migration. Young flat-fish live, as is well known, for the most part, in shallow inshore waters, called *nurseries*, and some of the largest North Sea nurseries are those off the Dutch coast. The facts as to the summer migration tend to show that the English plaice fisheries to some extent depend for their supplies on these inshore grounds. On the West Coast certain nurseries are closed to all kinds of trawling on account of the large proportion of undersized fish met with; there is a closed area off Blackpool, for instance. In the Irish Sea from 30 to 40 per cent. of the marked plaice have been recaptured, though in some cases fishermen are reluctant to report marked fish captured by them. Off the Cumberland coast some of the inshore trawlers, believing the experiments had for their object the imposition of new restrictions, did not report marked plaice taken in their nets. A number of plaice were marked and liberated in Luce Bay, an area on the south coast of Scotland closed to all kinds of trawling by by-law of the Scottish Board. A sufficient number of these fish were recaptured on other grounds in the Irish Sea to prove that the waters of this bay serve as a preserve for mature fish which migrate offshore to spawn in the early spring, when the sea temperature in Luce Bay is much lower than on the offshore grounds.



11. THE HENSEN VERTICAL NET

a. Conical headpiece
b. Fishing part of net
c. Bucket *d*. *e*. *f*. Supporting rings

Can the Sea be Depleted of Fish? One of the vexed questions of the sea fisheries of recent times is that of *over-fishing*. It would perhaps be more correct to say that the question of over-fishing has been with us for some considerable time, but that it has only recently become acute. The question can best, perhaps, be put in the following form: Can man, by his efforts, so upset the balance of Nature as to render further fishing unprofitable? That there must be some reason for supposing the answer to be in the affirmative would seem to be an obvious deduction from the numerous Acts of Parliament—and local by-laws passed in pursuance thereof—which have for their object the regulation of the sea fisheries. The various restrictive enactments which have for their object the protection of immature fish, or the prevention of destructive or wasteful methods of fishing, have all been passed as a result of the outcry against over-fishing and the alleged depletion of the sea. Restrictions as to the sizes and conditions under which fish may not be removed from a fishery, the regulation of implements of fishing, and the enactment of close times, all have resulted largely, but not entirely, as a consequence of the alleged vanishing of the harvest of the seas.

Statistical Evidence Accumulating If the deterioration of the fishing grounds is a fact, then one would naturally expect to find evidence of it in the statistical returns which have been furnished from year to year by the Government departments concerned. Unfortunately, there is reason to believe that the statistical evidence has not in the past been collected with sufficient care to render any results obtained from its analysis reliable; and it is only since the establishment of the international council that statistical evidence of the condition of the fishing grounds has gradually been accumulated. In addition to the customary record of the value and quantity of fish landed, what is known as *ichthyometric data* are collected. The market statistics are carefully analysed; samples of certain kinds of fish such as plaice and haddock are weighed and measured. Voluminous reports dealing with these statistics have been published from time to time. Those by Professor d'Arcy Thompson on the Aberdeen trawling statistics may be taken as a model.

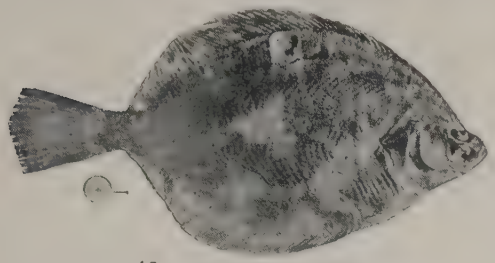
Professor Thompson deals at length with the sizes of plaice in the Aberdeen market, according to the various grades of market classification and for various localities. He shows, among other things, that the plaice from the near grounds off the East Coast of Scotland are smaller than those from any other grounds frequented by Aberdeen fishing-vessels, but are, nevertheless, considerably larger than the average size of plaice landed by English trawlers at the great English markets. The gradual decrease of plaice, both in the gross quantities landed at Aberdeen and in regard to the average catch per voyage and per hundred hours' fishing, is dealt with at some length. Finally, the increasing quantities of the so-called "extra small" plaice landed of recent years at Aberdeen are particularly dealt with. Professor Thompson is strongly of opinion that the destruction of these very small plaice is detrimental to the fishery, and that it yields no commensurate benefit to the trade.

It is impossible to deal here with the results of the enormous amount of statistical information which has been collected within the last few years, but, on the whole, and subject to certain exceptions, they show a steady if gradual depletion of the stock of some of our most valuable marine food-fish.

Fishing is Skilled Labour. Fishing is not unskilled labour. More is to be credited to the personal experience and local knowledge of the skipper than is generally supposed; and it by no means follows that a trawl shot at hazard in a given locality can be relied upon to give a fair average sample of the number of fish, even for a very limited area around that spot. Only extremely limited areas can be satisfactorily investigated by means of a steamer specially told off for the work. While there are undoubtedly many practical problems which can only be satisfactorily investigated from a specially equipped steamer—such as, for instance, the determination of the vitality of undersized fish caught in a trawl, or the relative destructiveness

to young fish of various-sized meshes—we would advise caution as to the acceptance of deductions as to over-fishing, based on evidence accumulated from one or even a few steamers. The only reliable method is the analysis of the commercial returns, supplemented by ichthyometric work on the trawlers and in the markets.

Collecting New Statistics. With the discovery of new fishing grounds off the Icelandic



12. A MARKED PLAICE
This fish was liberated off the River Mersey on Nov. 12th, 1904, and recaptured in the River Lune on Dec. 2nd, 1904.

coast, in the Bay of Biscay, and even so far distant as the White Sea and Morocco, there is no cause for surprise in the fact that the gross quantity of fish landed in the British Isles shows a continual and gradual increase. At the same time, the quantity of fish on and near the British territorial waters may be on the decrease, and evidence of fish caught in or adjacent to these waters is urgently needed. Steps have been taken by the Board of Agriculture and Fisheries and the Scottish Fishery Board for the careful and accurate record of the locality of origin as well as the port of landing for all sea fish, and, in addition, separate records of the fishing voyages of first-class fishing vessels are now kept There can be no shadow of doubt that this is an extremely valuable method of obtaining evidence of the condition of the fisheries.

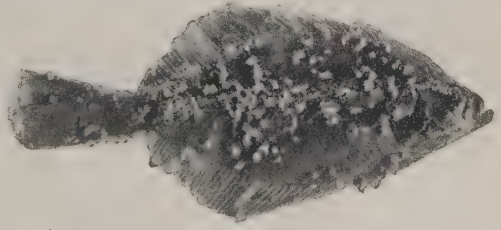
Protection of Immature Fish. In many methods of fishing, notably in *shrimping*, large numbers of undersized fish are caught, and in many instances these immature fish are unmarketable. Every haul with the shrimp-trawl in our inshore waters brings up, in addition to the shrimps, a number of small plaice, dabs, soles, herring, codling, and whiting, the number and species varying according to locality and season.

These fish are unmarketable, but if allowed to remain in the sea a proportion would presumably become of marketable size and be captured by the fisherman. If the shrimp trawls are hauled at short intervals and the net rapidly cleaned and the young fish promptly returned overboard, it is certain that a very large percentage of the flat fish would be uninjured, and they may be seen swimming away as soon as they are replaced in the water. With regard to the round fish, it may be said that they are far more susceptible to injury, and extremely prompt measures are requisite to secure that any reasonable proportion be returned to the sea alive. There can therefore be no reasonable doubt that many millions of undersized fish are captured by shrimpers in their trawl-nets, push-nets, and shanks; and formerly a very large proportion of these were destroyed. The process of separating the shrimps from the fish and other débris caught in a trawl is accomplished by *riddling;* and where such riddling is promptly done, and the débris and fish returned overboard immediately, little harm is done. Of course, the shrimper naturally selects ground where shrimps are most abundant, and the young fish are caught accidentally; and in this respect the shrimper differs from the whitebait fisherman, who intends to capture undersized fish for which he readily finds a market.

How to Stop the Needless Destruction of Fish. Where there is a market for undersized or immature fish, though it might be advisable to have the fishery carried on within reasonable limits, since obviously a certain proportion of adults must survive to propagate their kind, it would be as absurd to prevent it altogether as it would be to stop the sale of veal or lamb.

But in cases where the fish are caught accidentally or sold for manure or needlessly destroyed, prompt measures are necessary for the maintenance of the fishery; and where destruction is of a gratuitous nature there can obviously be no sympathy with the person responsible for the damage, though at the same time, where he is carrying on a bona-fide business, it becomes necessary to interfere with him as little as possible.

The most practicable method of dealing with a problem of this kind is to interfere as little as possible with the implements of fishing, but to see that they are not needlessly destructive, and in any case to see that they are used in a proper manner. The prevention of landing of fish under a certain size might stop the fishing *for* undersized fish, as distinguished from shrimping, where the undersized fish are accidentally present. But in many cases, on grounds frequented by undersized fish, there is a certain proportion above the legal minimum, and it still might be profitable to fish these grounds, throwing overboard the small fish. Most of these small fish would be killed and no advantage would accrue. Various enactments have been proposed for dealing with his evil, which is admittedly serious. Bill after Bill has been introduced into successive Parliaments, but, not being party measures, they have had no chance of being passed. But in the territorial waters local regulations, confirmed by the central authority (the Board of Agriculture and Fisheries), have dealt with and, to some extent, undoubtedly checked this wholesale and wasteful destruction. The establishment of reserve areas, either within or outside the territorial waters, where spawning or



13. FLOUNDER ATTACKED BY A SPOROZOAN PARASITE

immature fish are known to congregate, would be the most effectual means of preserving a continuity of our fish supply. But whether such an arrangement is within the sphere of practical politics is another question.

Artifical Hatching and Rearing of Marine Food-fishes. A certain section of scientific experts, being firmly convinced that a depletion of the seas was in operation, suggested

that man might, by artificial hatching and rearing of the fry of economic fish, restore the balance of Nature. The initiative with regard to the erection and equipment of marine hatcheries is due to the United States authorities, who regarded this plan as more suitable than attempting to prevent the destruction of immature fish by restrictive legislation—an alternative method which had been suggested as a remedy for over-fishing and its evil consequences. The whole method of working of the marine pisciculturist is, we believe, based on fallacious reasoning. But this is not the place to enter into destructive criticism of his efforts; we are merely content to describe what is claimed to have been done.

1500 Million Fish Hatched. The United States Fish Commission annually hatch and liberate about 1,500,000,000 fish fry, the principal salt-water fish dealt with being cod, flounders, and lobsters. The Canadian hatcheries deal mainly with cod and lobsters. The European countries which have adopted artificial hatching are Norway, Scotland, and England. The methods in vogue for obtaining fish eggs vary in the different establishments, but in England the mature fish are obtained by trawling from a special steamer some months before the spawning season begins. These fish are kept in tanks or open-air ponds attached to the hatcheries, and are claimed to constitute a reserve of spawners. The eggs are artificially fertilised, and then placed in the hatching-boxes, there to undergo their incubation.

The hatching-boxes are kept in constant motion by an automatic arrangement, and a current of sea water is maintained through the boxes. This serves the double purpose of oxygenating the eggs and preventing their settling. Up to the present no successful attempts have been made to rear the fish, the fry being set free a few days after hatching, or never later than after the absorption of the yolk-sac. These larvæ are (or should be) liberated on the off-shore spawning grounds, their natural habitat. No satisfactory evidence has yet been adduced that sea-fish hatching is an economical success. Originally it was doubtless worth an extended trial, but until rearing the fish as well as hatching them has been accomplished, opinion must be reserved as to the efficacy of this method of replenishing the sea.

Fish Diseases and Parasites. Fish, like other animals, are subject to "the ills that flesh is heir to," but the alarmist statements that have of recent years appeared in the public Press are quite without foundation, and it may once for all be said that no article of diet can be regarded as so absolutely free from disease as sea fish. The complaints from which fish suffer may be grouped under two headings—firstly, the attacks of parasites, either attached to the body externally (*ectoparasites*), or dwelling in the inside of the fish's body (*endoparasites*); and secondly, infectious diseases due to the presence of vegetable organisms (*bacteria*) or animal organisms (*sporozoa*). Of course, both bacteria and sporozoa are, strictly speaking, endoparasites.

The important question as to how far, if at all, the communicability of diseases from fish to man or vice versa is possible merits a brief notice. It is obvious that this question of the purity of fish as a food supply has the most important practical bearings, and the "scare" with regard to the connection of oysters and typhoid is a case in point. That shellfish may, under certain circumstances, be the means of communicating such a disease as enteric or typhoid fever to human beings seems to be well established, and not only oysters, but mussels and—though less certainly—cockles may occasionally be held responsible. This is, however, never due to the fact that the oyster is itself "suffering" from the complaint, but rather that the typhoid bacillus is accidentally present either in the food of the oyster or in the sea water enclosed in the shell. Modern research tends to prove that if reasonable care be taken in the selection of the site for bedding oysters, and if ordinary cleanliness be secured in the handling and preparing of the bivalve for the market, the risk of pollution is infinitesimal, and certainly not greater than is the case in many other articles of consumption, notably milk. The danger is reduced to vanishing point if the shellfish be thoroughly cooked.

Fish and Human Diseases. Within the last few years considerable attention has been devoted to the study of the diseases of fish, and a review of the literature devoted to the subject is rather a source of satisfaction than dismay. The diseases such as smallpox, phthisis, and dropsy which have been popularly attributed to fish disappear or become something quite different on closer inspection.

Fish, however, are undoubtedly attacked by such parasites as threadworms, tapeworms, and leeches. The worms are generally found in the intestines, and are removed with them. Leeches are rare, and drop off when the fish are caught. Certain crustacea (parasitic copepoda) attack fish, and are found attached to the gills, fins, eyes, and even in the nostrils. They, however, in most cases, only cause a temporary inconvenience. There remain, then, a few diseases attributable either to bacteria or sporozoa. An instance of the former is the well-known *salmon disease*, which was formerly thought to be due to a fungus (*saprolegnia*). An instance of the latter is shown in the figure of the flounder [13]. In all cases where a fish suffers from complaints of this kind, the body is unsightly, being marked with blotches or swellings which would immediately cause it to be rejected for food. In conclusion, though isolated instances of fish (chiefly fresh-water species) suffering from disease are from time to time recorded, in no case is the disease identical with any human complaint, and in every case spots or swellings are visible which would render the fish unmarketable. Nothing is said about unwholesome fish where the deterioration is due to the fish having been kept too long Naturally, fish, like all other perishable articles, require to be eaten in as fresh a condition as possible.

Preparation of Fish for the Market. Fish, if not speedily placed on the market, deteriorates rapidly, and hence we find a large number of methods of preservation. All these methods depend for the efficacy upon the necessity of eliminating the action of the bacteria responsible for the putrefactive changes which so rapidly take place. A second and most essential purpose to be borne in mind is the preparation of an article which shall at the same time be palatable and be capable of retailing at a reasonable price. The methods of preserving fish fall under four main heads—namely, by *ice*, *salt*, *smoke*, or *canning*. It must be understood that these methods are not absolutely distinct; a fish may, in the course of preparation for market, go through two or more of these methods in succession. A description of the multitudinous

modes of manipulating the raw material would fill the pages of a considerable volume, and therefore the only accounts given here are those which are practicable on a small scale. *Canning*, which requires special plant and is quite distinct from fishing proper, is not touched upon.

The "Finnan Haddies." There are, broadly speaking, three essential stages in the preparation of "finnans." These are splitting, salting, and smoking. The operation of *splitting*, to be rapidly and efficiently performed, requires actual practice. The head is removed, the fish split down the back, and eviscerated. It is then *salted* for about half an hour in strong brine, then drained, and afterwards smoked. The smoking is now carried on in small houses built for the purpose, the fish being spread open and suspended in tiers. The fuel used is peat, and the operation is continued without interruption for from four to six hours, during which period the fish requires constant attention. The fish are generally put up in boxes of the average weight of 40 lb. The barrels are about four times as heavy. For export purposes "finnans" are *canned*, but as these fish must be cooked, or at least boiled, before canning, in addition to the processes above described, it seems a misnomer to call them "finnans."

In addition to finnans there are other varieties of prepared haddocks, notably "smokies," where the fish are smoked over a hot fire, with abundance of smoke, until they have taken a golden colour; and "pale smoked haddocks," where the fish are but slightly smoked for immediate consumption.

The Preservation of Herring. The four chief methods of preserving herring are best enumerated under the headings by which the resulting product is known to the public—namely, *pickled herring*, *kippers*, *bloaters*, and *reds*. The *bloater* is intended for immediate consumption, and may be described as a round or unsplit herring which has only been slightly salted and smoked. The fish, as soon as possible after capture, are dry-salted for from six to twenty-four hours—the time being longer if the fish be fat—and afterwards smoked. The *red* is generally prepared for foreign consumption, and large quantities are exported to the Mediterranean. For this trade the herrings are salted in brine for about two days, and then smoked for a fortnight. The wood and sawdust used is of the "hard" variety, and from this the peculiar flavour of the red is derived. The red may be defined as a round herring, heavily salted, and smoked for a long time. They are packed chiefly in barrels and half-barrels, the former containing from about 500 to 600 fish.

Kippers and Pickled Herrings. *Kippers* are first of all split and eviscerated, then salted in strong brine for from a quarter of an hour to an hour, then spread out and smoked over hardwood shavings. The time for smoking varies, being longer at Yarmouth than at Aberdeen. *Pickled herrings* are more numerous than all the other varieties put together. These fish have their gills and intestines removed. They are then brine-salted and packed in barrels and half-barrels. In Scotland these herrings may be tested by the Fishery Board. If the merchant desires a certificate of the quality of the fish in his barrels, an officer of the Board opens and examines samples of these barrels, and if the contents come up to the required standard a brand is burned into the head of the barrel. A barrel generally contains 300 lb. of herrings, and each barrel is packed with great care, with alternate layers of fish and salt.

Fish Markets. Broadly speaking, the marketing of fish is left to a special class of individuals —fish auctioneers and salesmen. Even fresh fish is rarely disposed of by the fisherman himself, and the bulk of preserved fish and fish products he never sees. There are, of course, certain exceptions, such as potted shrimps.

Fish that is landed at any of the larger fishing ports, such as Hull, Grimsby, Billingsgate, or Aberdeen, is sold by auction on the quay. The fish is sorted into baskets or other receptacles, or may even be spread out on the quay floor as at Aberdeen, and the sale is invariably held by auction at an early hour in the morning.

Even fish that is landed by smaller boats at the quieter fishing ports is, to a very large extent, sent to large centres to be disposed of by auction, some occasionally even returning over the same ground for local consumption. The marketing of fresh fish is now such a special occupation that there is a considerable amount of truth in the complaint of visitors to seaside resorts, like Llandudno or Tenby, that they have to wait for the train from Grimsby before they can procure any fresh fish. Many markets for preserved fish are met with abroad, pickled herrings being an especial favourite with the Latin nations.

Oyster Culture. On the Continent *oyster culture* forms a considerable industry, absorbing a large amount of capital and affording employment to thousands of people; but in England, for various reasons, this industry has not been developed to the same extent. The success of oyster culture depends to some extent, as for instance at Arcachon, on the natural physical advantages of the locality. At Arcachon there is a large inland sea of about 30,000 acres area, which communicates with the sea by means of a narrow entrance, through which the tide ebbs and flows. In this lake the oyster reproduces itself naturally. The young stage of the oyster, known as the *fry* or *spat*, is of microscopic size, and swims about in the water for a time, and eventually settles down on suitable objects, there to develop into an adult oyster. [See NATURAL HISTORY, pages 3227-29.]

Spatting. The success of oyster culture depends upon the simple fact that the spat can easily be collected upon suitable objects. The oyster reproduces itself in spring or early summer, and the free-swimming stage lasts for about a week. At the time settling-down process begins, receptacles or collectors are placed in position. The Romans used bundles of twigs; the Dutch use earthenware tiles; in France the collectors are crates of similar tiles coated with a cement of lime and sand, which offer a convenient adhesive medium for the *spat*. The tiles are arranged in rows inside large cases, and in Arcachon alone about 12,000,000 tiles are annually laid down for this purpose. The spat is left on the tiles until the following October, when the young oysters are about the size of a finger-nail, at which stage they are known as *seed oysters*.

Rearing and Greening. They are now removed from the tiles and are taken in hand by the "éleveurs," who rear and fatten them to a marketable size. This is done by arranging the *seed* on flat trays of galvanised wire netting, which are placed in shallow oyster "parcs" in which the tide circulates. Great care is taken with the rearing process, the oysters being constantly looked after by men and women, who inspect the trays at low water and remove impurities and enemies, such as starfish. Thinning out is soon necessary,

the growing oyster being removed to other trays or transferred to the floor of the "parc," which is often suitably prepared for their reception.

The process of *greening* is undertaken at Marennes, where the oysters are kept in muddy salt-ponds, in which they gradually become green, owing to the presence of a particular diatom in their food, and acquire a peculiar, delicate flavour.

Board of Trade Certificates for Fishermen. According to the provisions of the Merchant Shipping Act, 1894, no trawler of 25 tons or upwards shall go to sea from any port in the United Kingdom unless there is on board a duly certificated skipper and second hand. By an order of the Board of Trade the requirements of the Merchant Shipping Acts in regard to the certification of skippers and second hands is extended from July 1, 1910, to all liners and drifters of 50 tons gross tonnage and upwards which are propelled by steam or other mechanical power.

Every fisherman with a spark of ambition will be interested to hear particulars of the certificates issued and the best way to set about obtaining one. The Board of Trade examines candidates for certificates of competency, and there are three different certificates to be obtained by any deep-sea fisherman who is prepared to sacrifice a little of his leisure. These certificates are for second hands, skippers, and extra skippers.

A Second Hand's "Ticket." To obtain the certificate which is issued to *second hands* who fulfil the necessary conditions and pass the required examination, several preliminary qualifications are requisite. The candidate must not be less than nineteen years of age, he must have served at least four years at sea, of which two years must have been on board a deep-sea fishing boat. If he has served his time, the candidate should apply to the nearest Mercantile Marine Office for a form of application (s. 20), and he must take care to fill this form up properly. When the form is returned to the office the candidate must attach to it his testimonials of general good character, and of sobriety, experience, ability, and good conduct on board ship. A fee of 1s. is charged for the examination. The candidate will be examined as to his vision, and, in addition, the rule of the road at sea, the marks on the lead-line and the use of the lead, taking bearings by compass, ability to use a chart, and generally as to the duties of a second hand. The candidate must have a good knowledge of all the articles of the regulations for preventing collisions at sea. Questions regarding the rules of the road at sea are illustrated by means of models of vessels; and various coloured balls, representing lights, are used to represent vessels at night. Mates or second hands are also tested as to their abilities in reading, writing, and arithmetic.

A Skipper's "Ticket." Candidates for certificates as *skippers* must have served five years at sea, of which one year must have been as certificated second hand on board trawlers of 25 tons tonnage and upwards, or as second, third, or fourth hand of a steam or sailing liner or drifter of similar tonnage. An applicant for a certificate as skipper must be not less than twenty-one years of age. In addition to the subjects enumerated for second hands, skippers are required to be acquainted with general duties required for skippers, such as getting under way, what to do when the engines are broken down, or when the vessel has sprung a leak, or when the rudder has gone, or on the use of a floating anchor. They are also required to make themselves acquainted with their civil duties under the Merchant Shipping Act of 1894; for instance, as to the returns of the list of crew, or as to agreements or apprentices' indentures. For extra certificates the applicant must show a knowledge of the use of the quadrant, and be able to take observations, to read on and off the arc, to find the index error by the horizon, and to determine the latitude by the meridian altitude of the sun.

Signalling and Compass Deviation. Voluntary examinations in signalling and compass deviation are also open, without fee, to all fishermen holding or who have passed for a certificate of competency as second hand or skipper of a fishing vessel. If the candidate be successful, the fact, with the date and place of passing, will be recorded on his certificate. Candidates may be examined at any port where examinations of masters and mates or special examinations of fishermen are held, on making application on Form Exn. 2. Various County Councils and other local education authorities have now instituted classes in subjects for certificates for management of fishing boats; and as a good deal of the instruction is of a practical nature, and cannot be learnt from a book, the candidate is advised to make local inquiries as to such classes.

Sea Fishery Law. The history of the legislation applied to the fisheries does not afford the student very pleasant reading. All the older and some of the more recent legislative efforts of Parliament were based on a profound ignorance of the technique of the fisherman's craft. We are, however, not so much concerned with what the legislation has been as to what it is now, and along what lines its future development may be expected. The words of Professor Huxley (inaugural address, Fisheries Exhibition, 1883) have lost none of their force at the present day; and as they embody the maxims or axioms which are fundamental, they may well be reproduced here:

"Every legislative restriction means the creation of a new offence. In the case of fishery, it means that a simple man of the people, earning a scanty livelihood by hard toil, shall be liable to fine and imprisonment for doing that which he and his father before him have, up to that time, been free to do. If the general interest clearly requires that this burden should be put upon the fishermen—well and good. But if it does not—if, indeed, there is any doubt about the matter—I think that the man who made the unnecessary law deserves a heavier punishment than the man who breaks it."

The Necessity for Knowing Fishery Law. At the present day, when considerable capital is devoted to the building and equipment of large and powerful vessels which fish to some extent near the territorial waters of foreign countries in addition to the waters of England, Scotland, and Ireland, the skipper of such a boat has to be acquainted with a not inconsiderable body of legislative enactments, which are here briefly summarised.

In the first place, the whole part of Part IV. of the Merchant Shipping Act of 1894 deals with fishing boats; but as the skipper of every English trawler over 25 tons tonnage undergoes an examination as to his knowledge of this section of the Act before he obtains his captain's certificate, it will be unnecessary to do more than point out the main features of the Act. All fishing boats are (or should be) conspicuously numbered and lettered, and when fishing at night should carry certain lights, the details being given in the Act.

Other regulations relate to the fishing boat's register, to discipline, to apprentices, and agreements with seamen. This Act, of course, applies to British fishing boats even outside British territorial waters. Other regulations for fishing may be divided into two groups: (1) Those which are enforced on the high seas, or beyond the territorial limits. (2) Those which are enforced only within British waters.

Regulations in Territorial Waters. There are three Acts, and a Convention between Britain and Denmark, which define the territorial waters within which His Majesty's subjects have the exclusive rights of fishing. The Convention Act of 1843 defines certain waters which are to be reserved for French and English fishermen in their respective countries, and here, in addition to three geographical miles from low-water mark, we find bays, the mouths of which do not exceed ten geographical miles in width, also reserved, and the limit is to be reckoned as being distant three miles to the seaward of a straight line drawn from low-water mark off one headland to low-water mark off the other headland of such bay respectively. By a subsequent Act of 1868, which, like the Act of 1843, was intended to carry out a Convention between England and France, we find a similar definition, except that the straight line across the bay is to be drawn from "headland to headland," no mention being made of low-water mark. This convention was never carried out by France, the necessary legislation to make it operative never having been passed. A later Act (of 1883) defines exclusive rights of fishery as regards bays, and states that the distance of three miles shall be measured from a straight line drawn across the bay in the part nearest the entrance at the first point where the width does not exceed ten miles. This Act carries out a convention between England, Germany, Belgium, Denmark, and Holland. No definition of a "bay" is given, but presumably any indentation of the coast line is a "bay" within the meaning of the Act. In the Anglo-Danish Convention of 1901, the distance may be measured not only from low water of the coast, but also from dependent islets, rocks, and banks.

It must not be assumed that the exact delimitation of the territorial waters is a point of merely theoretical importance. Some of the laws restricting steam trawling in foreign territorial waters are very stringent. For instant, trawl fishing within the territorial waters of Iceland or the Faroes is punishable by a fine not exceeding 4000 kroner (£220), together with forfeiture of all the fishing gear, including the drag ropes. That heavy fines are not infrequently inflicted English skippers know to their cost. Even to enter Icelandic or Faroe waters with a trawl on board not stowed away, is punishable by a fine of 2000 kroner, and the ship, catch, and fishing gear may in either of these cases be seized and sold to cover the legal expenses.

Regulations for Home Waters. Apart from the question of *territorial waters*, which are reserved to native fishermen, we have to deal with restrictions applied in the British Islands, and at the outset a fundamental difference is to be noted. For England and Wales, although the Board of Agriculture and Fisheries is the central authority for sea fisheries, the by-laws regulating the industry are formulated and administered by local Sea Fisheries Committees, which were called into existence by the Sea Fisheries Regulation Act, 1888. Although these by-laws are formulated by the committees they need the sanction of the central authority before they become operative. In Scotland and Ireland, on the other hand, the administration of by-laws is controlled by a central authority, and this distinction is accompanied by an extension of the area under control, for whereas in England and Wales by-laws only apply to the territorial waters, in both Scotland and Ireland the jurisdiction of the central authority extends beyond this. Naturally this extra-territorial authority can only be enforced against British subjects—at any rate while their vessels fly the British flag.

In Scotland trawling is absolutely forbidden in territorial waters (the Herring Fishery [Scotland] Act, 1889); it is also forbidden in certain Scottish waters outside the three-mile limit, notably in the Moray Firth and the Firth of Clyde.

In Ireland no extensive advantage has been taken of Section 3 (1) of the Steam Trawling (Ireland) Act of 1889, which allows the inspectors of Irish Fisheries to prohibit "beam-trawling or other trawling within three miles of low-water mark of any part of the coast of Ireland, *or within the waters of any other defined areas* specified in any such by-laws, and subject to any conditions or regulations contained in such by-laws." There are, however, certain extra-territorial waters closed under by-laws made in pursuance of this section, notably off the coast of Waterford.

By the Trawling in Prohibited Areas Prevention Act, 1909, no fishing vessel, foreign or British, may land or sell or attempt to land or sell any fish in the United Kingdom if such vessel within two months previously shall have been employed in either trawling or taking fish on board within any of the prohibited areas of the sea adjoining Scotland or Ireland.

Fishing Grounds at Home and Abroad. In England, trawling from steam vessels is practically prohibited within three miles from the shore; trawling from sailing vessels is only allowed with nets the meshes of which are a certain size, and there are in various localities regulations as to the tonnage of sailing trawlers. Certain grounds are closed to all kinds of fishing but lining. There is at present no regulation as to the size at which *sea fish* may be landed or exposed for sale, but such regulations are in force for shellfish.

Shellfish are frequently protected by closed seasons, and berried lobsters and crabs may not be removed from a fishery. Broadly speaking, the local fisheries committees absolutely prohibit wasteful and destructive methods of fishing. The powers of district committees are extensive with regard to prevention of certain methods of fishing, or the regulation of fishing implements, but do not extend to imposing a size limit for sea fish.

Steam trawler skippers who fish in the vicinity of foreign waters have to be careful. As a rule, the fines inflicted are excessive, being far above the modest £20 which is the maximum "penalty" in England and Wales; moreover, either to be in foreign waters with implements of fishing on board not stowed away or with the *intention* of fishing is in some cases punishable. That this regulation may at times be pushed to, or even beyond, its logical limits is evidenced by a decision of the German Appeal Court, at Leipsic, which decided in the case of the smack "Lady Godiva" that the presence of a foreign fishing boat in German waters with the *intention* of fishing was an offence equivalent to that of actual fishing.

J. TRAVIS JENKINS

General Drawings. Detail Drawings. Frames for Vertical and Horizontal Engines. Machine Tool Frames. Crane Frames. Engine Details.

MACHINE DESIGN

General Drawings. Figure 128 is a *general arrangement drawing*, made after the details have been worked out on separate sheets, and it serves as a guide for the complete assembly and erection of the machine. The foundation blocks are fully dimensioned in the side elevation, and the holding-down bolts are shown in position. The small plan view gives the relative position of the blocks. The two sleepers, A, A, connect the outer foundation blocks to the centre one located under the crane-mast; such a foundation is substantial and permanent. Very frequently, however, this type of crane has only temporary foundations, such as timber seatings and weights simply laid across the ends of the sleepers. The mast is furnished with top and bottom pivot pins, and the backstays support the top pivot. The crane gearing is seen in position at the lower end of the mast; there is a train of spur gear from the handle shaft, B, connecting to the barrel, C, which coils the hoisting-chain. A clutch, D, and gears, E, couple the hoisting barrel C to the barrel, F, upon which is coiled another chain, which varies the radius of the jib by altering the length of the ties, G, this movement being termed *derricking*, or *luffing*, the jib. The revolving or slewing gear is arranged behind the mast, and consists of spur and bevel gear, connecting to the curb ring, H, which is bolted to the bedplate underneath the mast.

Detail Drawings. The drawings from which machines are actually manufactured are termed *detail drawings*, each part of the machine being fully delineated and dimensioned upon one or more sheets. Castings have a sheet to themselves, forgings have a separate sheet, plating another, and so forth, the object being to provide each works department with drawings that concern the department alone. The principal detail drawing is the one which depicts the main framework of the machine. Framings are made of various metals and in various forms. Machine tools and engines are invariably built with cast-iron frames, although exceptions are to be found, the chief virtue in such frames being rigidity, a factor that cannot be calculated in anything like an exact manner.

Steam-hammer Frame. A *detail drawing* of a frame for a steam hammer is given in 129. The views presented comprise a side elevation, a back elevation, a plan of the top, two sections, and separate details of bosses. The head of the frame is arranged to receive a square bolt, which is cottared in place; the upper end of the bolt passes through the foot of the hammer cylinder, as well as the two outer bolts, and holds it down with a nut in the usual way; there are two such frames, one on each side of the hammer block. The section of the frame is what is termed H section instead of a hollow rectangle; the inner flange throughout is heavier than the outer one, it being subjected to severe compressive shocks; three cross ribs are arranged to tie the flanges together, and to stiffen the web plate. The taper allowed on the flanges is considerable, and large radii are put in the corners. This is done in order to ensure a sound casting, free from initial stress due to contraction, and also to enable the pattern to be drawn easily from the mould, and so produce a smooth outline. The front of the frame at the bottom of the hammer guides is specially heavy, to prevent fracture at this point. The bosses are for the pivot pins of the working levers. The base of the frame is provided with facing strips and bosses for the foundation bolts, and the holes are slotted so as to permit adjustment endwise. The slope of the upper part of the frame is obtained by prolonging the line, as shown [129], until it forms a tangent with the inside radius of the lower part. The drawing is reproduced from an actual working drawing supplied by Messrs. Thwaites Bros., of Bradford, Yorkshire.

Mild Steel Frames. Mild steel frames are not used for machine tools proper, on account of their elasticity and consequent lack of rigidity; they do, however, enter into the construction of many appliances used by engineers, and in such appliances have a far greater value than cast-iron frames. Locomotive frames, carriage frames, large crane frames, furnace charging machines, etc., are examples in which cast iron would be a failure. Fig. 130 illustrates the steel frame of an overhead traveller as used in most engineers' shops. It consists of a pair of girders, A and B, secured to two cradles, C and D, which are mounted upon double-flanged wheels. These wheels are set to run upon rails which are built on the side walls or columns of the shop. The girders A and B are provided with rails which form the track for a trolley or crab, which is fitted with hoisting mechanism and necessary tackle. The machine is driven electrically, a separate motor being applied to each movement. The example [130] is for a high-speed electric traveller, and it is therefore specially braced to meet the stresses due to inertia in starting and stopping. The auxiliary girders, E and F, are stayed to the main girders A and B by bracing bars on the lower boom, in such a way as to afford them lateral support; the upper booms have chequer plates connecting them, instead of bracing bars, and these incidentally form a platform for the attendant, and are protected by handrailing as shown at G. The distance from centre to centre of the main rails, H, is termed the span, and the distance apart centre to centre of the wheels, I, is the wheel base, and is usually one-fifth of the span. The depth of the main girders at the centre of the span is generally one-fifteenth of the span.

The upper elevation shows the main girder with its joints. The web plate is made in four lengths for convenience, while the boom plates and angles are made in two lengths; the central joint is shown in plan. The next elevation is of the outer girder with the handrailing on top, the form of the bracing being known as the Linville, and being economical of material. The general plan view shows all the girders in position, as well as the cradles and platform. The two bottom left-hand enlarged views are details of the cradles,

while the right-hand bottom view is an enlarged section cut through the four girders at the centre.

Calculations. The main sections of the various members of such frames as **128** and **130** can be decided by calculations. In **128** the load on the jib and tie may be determined as described on page 389 in this group. The tie-rods and chains are tension members, and can have sufficient area allowed to permit a factor of safety of 8 to 1; the jib is a column, and should have a factor of safety of 6 to 1. The load on the backstay is found by taking moments about I; the forward moment is made up of the load multiplied by the full radius plus the weight of the jib multiplied by half the radius; adding these two moments together and dividing the distance, J, we get the load on the backstay (B1). The backstay may be either in compression or tension, according to the position of the jib in plan; as it is weakest in compression it may be proportioned as a column with a factor of safety of 6 to 1. The load on the sleeper and the mast is easily obtained by a simple diagram. Mark off the load on the backstay as K L on a scale of tons, and draw a vertical line from K till it cuts a horizontal line from L, meeting at M, then K M scales the load on the mast, and L M scales the load on the sleeper. Both mast and sleeper have alternatively tensile and compressive loads in a similar manner to the backstay, and they are proportioned for compression; the mast has to sustain in addition the load due to the hoisting and derricking chains, which also impose compressive loads.

Travelling Frame. In **130** we have the simple case of loaded beams or girders, which has been fully dealt with on page 510. The load on the main girders is made up from the actual load lifted by the traveller plus the weight of the movable crab and half the weight of the girders themselves. The cradles may be regarded as beams oi a length equal to the wheel base, and loaded at the two points at which the main girders are built in; each cradle has to sustain half the weight of the whole framework plus nearly the whole weight of the crab and load; the exact amount of this latter sum depends upon the nearness of the extreme position of the crab to the cradle. The outer girders have to sustain their own weight and half the weight of the platform, etc. When long spans are involved, the main girders as well as the outer girders are often designed as Warren or Linville braced members.

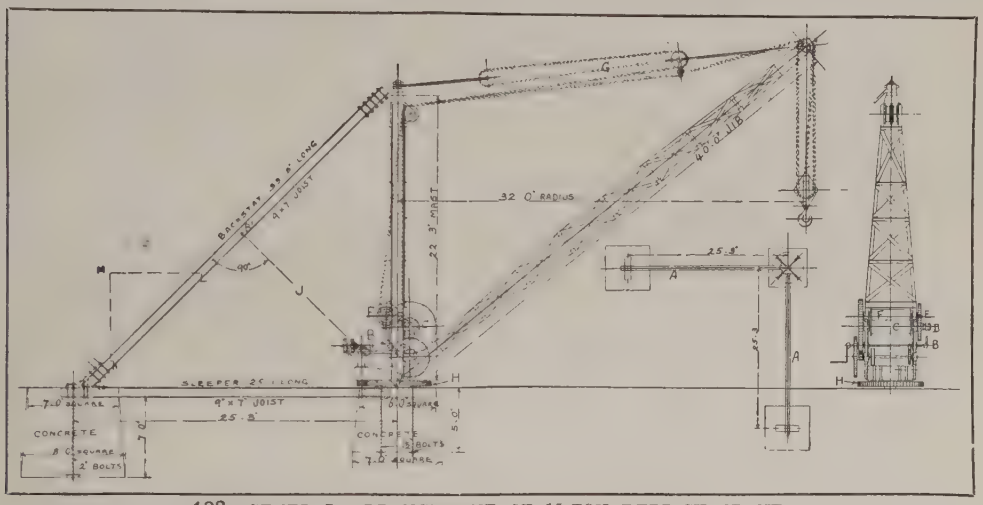
Cylinders. One of the principal *detail drawings* of an engine is that which represents a cylinder or cylinders. Fig. **131** shows a drawing of the high-pressure cylinder of a compound engine; the bore is 16 in. and the stroke of the piston is 36 in. The liner, A, is cast of harder metal than the cylinder body, and is forced into place by hydraulic pressure; the space, B, between the liner and the body is frequently used as a steam jacket—that is, live steam is admitted to the space in order to keep the temperature of the liner as uniform as possible. Small engines are not usually so made, but the cylinder body is simply bored out for the passage of the piston. The thickness of cylinder walls and liners is largely determined by practice; it is seldom less than $\frac{5}{8}$ in. for cylinders up to 10 in. bore; above 10 in. the following formula may be used:

$$T = \frac{D \times P}{3000}$$

where T = thickness required, D = diameter of cylinder, and P = steam pressure in pounds per square inch. It would not do to simply calculate the thickness necessary to withstand the bursting effort of the steam pressure; there must be sufficient metal to ensure rigidity and to stand re-boring after wear has taken place.

The cylinder ends and covers, C and D, are slightly thicker than the cylinder walls; the size and pitch of the studs or bolts which secure the cover affect its thickness to some extent. A good rule is to make the cover and the flange of the cylinder $1\frac{1}{4}$ times as thick as the cylinder itself, then the studs may be pitched $4\frac{1}{2}$ diameters apart for steam pressures up to 100 lb. per square inch, and $3\frac{1}{2}$ diameters apart up to 160 lb.

The diameter of the cover-studs is determined by calculating the load upon the cylinder cover, and apportioning sufficient area in the studs to meet the load; a safe stress is 3000 lb. per square inch of stud area. Care must be used in taking the area at the bottom of the thread. Studs

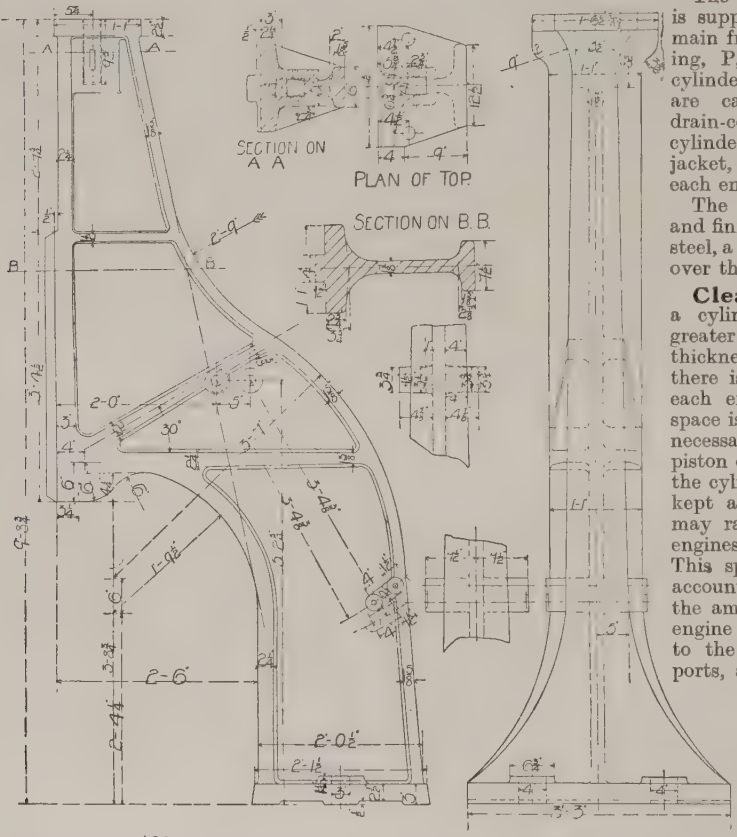


128. GENERAL ARRANGEMENT OF 15-TON DERRICK CRANE

smaller than $\frac{5}{8}$ in. diameter are not to be recommended for covers, as they are liable to damage in tightening up with an ordinary spanner. The covers of small cylinders are made with a single sheet of metal; for medium cylinders this sheet is strengthened with ribs, while for large cylinders the covers are made hollow with internal ribs.

The front cover, C, is cast with the cylinder, and has a stuffing-box, or gland, fitted for the piston-rod to work through.

The Valve-chest. The valve-chest forms part of the cylinder casting, is of sufficient size to accommodate the valves, and is provided with a



129. FRAME FOR A 25-CWT. STEAM HAMMER

cover, F, and stuffing-boxes, G and H; the box G is for the main-valve spindle, and the box H for the expansion-valve spindle. Steam-ports, U and K, are arranged from each end of the cylinder to the valve-chest; the ports L and M are for the exhaust steam.

The area of the steam-ports should be such that the steam does not flow at a greater velocity than 6000 ft. per minute, while the area of the exhaust port should allow a velocity of 4800 ft. per minute; the calculation is then:

Steam-port area

$$= \frac{\text{area of piston} \times \text{piston speed}}{6000};$$

exhaust port area

$$= \frac{\text{area of piston} \times \text{piston speed}}{4800}.$$

The length of the port—that is, the dimension measured at right angles to the length of the cylinder—is usually three-quarters of the cylinder diameter, and, this being settled, the width of the port is easily calculated from the area. The wider the port, the greater the travel of the valve, and it is sometimes necessary to make the port as long as the cylinder diameter in order to restrict the travel of the valve.

Steam is admitted to the valve-chest by the opening N, and exhaust steam leaves by the opening, O, both of these apertures having facings to which pipe-flanges connect.

The front end of the cylinder is supported by the end of the main frame casting; a foot casting, P, takes the weight of the cylinder to the foundation. Bosses are cast on for attaching a drain-cock at the end of the cylinder, a drain-cock for the jacket, and an indicator cock at each end.

The whole cylinder is lagged and finished off neatly with sheet steel, a dished casting being fitted over the back cover.

Clearance. The length of a cylinder is always slightly greater than the stroke plus the thickness of the piston—that is, there is a small space allowed at each end of the stroke. This space is termed *clearance*, and is necessary in order to prevent the piston coming into contact with the cylinder covers; it should be kept as small as possible, and may range from $\frac{5}{16}$ in. in small engines to $\frac{1}{2}$ in. in large ones. This space must be taken into account when calculating the the amount of steam used in an engine; the same remark applies to the capacity of the steam-ports, as these have also to be filled and emptied at each stroke. The total clearance space in an ordinary engine is usually from 3 per cent. to 6 per cent. of the actual volume swept by the piston in its stroke.

Piston. A piston is not quite such a simple article as would appear at first sight, and, as a matter of fact, there are scores of different types in existence. The simplest form is shown in **132**, and consists of a cast-iron body having three rings let into recesses; these rings are made slightly larger than the piston body, and are then cut through diagonally in one place; they are sprung into position on the piston and squeezed into the cylinder. The effort of the compressed rings is to expand constantly, and the resulting pressure on the walls of the cylinder makes the piston steam-tight. These are known as Ramsbottom rings, and are made of steel, but cast iron wears better. When made of the latter metal they should not be less than $\frac{3}{8}$ in. wide. Another form is shown in **133**, which presents a larger wearing surface than **132**. There are two rings, both of which are cut through

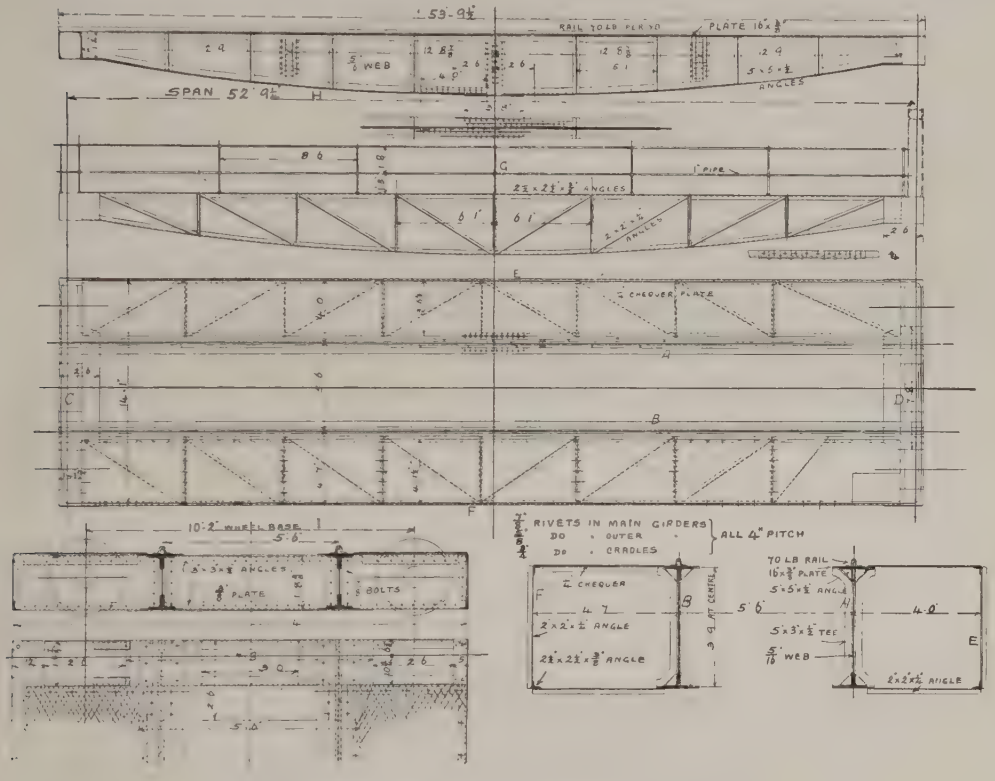
diagonally; a large spiral spring forces them outward to make them steam-tight against the cylinder. Such rings cannot be sprung into place, so the piston is made in two parts. The body, A, is a hollowed casting, as shown in **133**, and a loose ring, B, termed a *junk ring*, is secured to the piston body and serves to keep the rings in place. The depth of a piston may be from a quarter to half of the diameter of the piston.

The diameter of the piston-rod may be calculated by the use of the formula:

$$d = \cdot 013 \sqrt{DLP},$$

where d = diameter of rod,
D = diameter of cylinder,
L = length of rod in inches,
P = steam pressure in pounds per sq. in.

should have double guides. Looking at the diagram [**134**], and considering the engine to be running in the direction of the arrow, A, it is evident that both the piston-rod and connecting-rod are in a state of compression during the outward stroke; there is consequently a downward force acting on the crosshead, which is supported by the guide-bar. Now consider the return stroke, as shown in dotted lines. Here the piston-rod and connecting rod are in a state of tension, and consequently there is again a downward force on the crosshead. In fact, so long as an engine runs in one direction, the pressure on the guide-bar is always in the same sense. If the engine be reversed, then the direction of the force on the crosshead is reversed, and means must be provided to support



130. FRAME FOR A 35-TON ELECTRIC TRAVELLER

The attachment of the piston to the rod is usually made with a taper end and nut, as shown in **132**, but the taper is not absolutely necessary, for a parallel neck could be used and a shoulder or collar provided at the front end. A good taper is 1½ in. of diameter to 12 in. of length.

Crossheads. Crossheads are made in great variety; **136** shows a single slipper crosshead. The end of the piston-rod is swelled up to receive a half brass, and to accommodate the cap-bolts of the other half brass; provision is also made for bolting on the cast-iron slipper which runs between the guide-bars. The cap and rod are of mild steel, and the slipper is easily renewed when worn. Fig. **137** illustrates a heavier type of crosshead made with double slippers, to bear on double guide-bars; reversing engines it. The example given [**137**] is in general the same as **136**, but the slippers are larger, and are secured to the forging by studs and square keys as shown.

Adjustment for wear is made by means of wedges let through the keys; these wedges are moved by the nuts on their screwed ends; the main bolts have lock nuts similar to those in **36** on page 5405. Crossheads are also made to work in circular bored guides, the slippers being turned to suit.

Connecting-rods. Fig. **138** shows a connecting-rod of marine type suitable for working with the crosshead illustrated in **136**. The end is forked to embrace the crosshead, and the pin is kept from turning by means of a small stop-pin, as shown; the rod is circular, and is forged with a headpiece to take the gun-metal wearing-blocks. These blocks are divided at the centre, and are

held together with two bolts passing through them. An outer steel cap takes the bending movement due to the pull on the rod. The nuts on the bolts are similar to **36**, page 5405, but the steel cap receives the locking screw in place of a separate collar; in small engine work it is usual to use ordinary double nuts. Connecting-rods, like piston-rods, are subjected to alternate tensile and compressive loads. As they are weakest in compression, they are designed as struts or columns, but allowance must be made for the inertia of the rod itself, and this factor—especially in high-speed engines—makes the calculation quite a complicated one. The following empirical rule, due to Seaton, agrees closely with modern practice:

Diameter of connecting-rod in middle $= \frac{\sqrt{LK}}{4}$

where L = length of connecting-rod in inches
and $K = \cdot 03 \times \sqrt{\text{load on piston in pounds}}$.

The length of a connecting-rod is usually two and a half to three times the stroke of the piston. Figs. **139** and **140** show two other types of connecting-rod ends, both of which have solid ends and adjustable brasses. The former is adjustable by a cottar, and has a Babbitt lining; the flanges of the brasses are left off on the top and bottom on one side, so that the brasses may be put in place sideways. The example **140** is used for the crosshead end of the rod, in which case it enters a socket in the crosshead; it is adjustable by means of a wedge-block and nuts, as shown. The crankshaft end of a connecting rod is always termed the *large end*, and the opposite end, the crosshead end, is termed the *small end*.

Crankshafts. The Board of Trade rules for marine crankshafts are as follows:

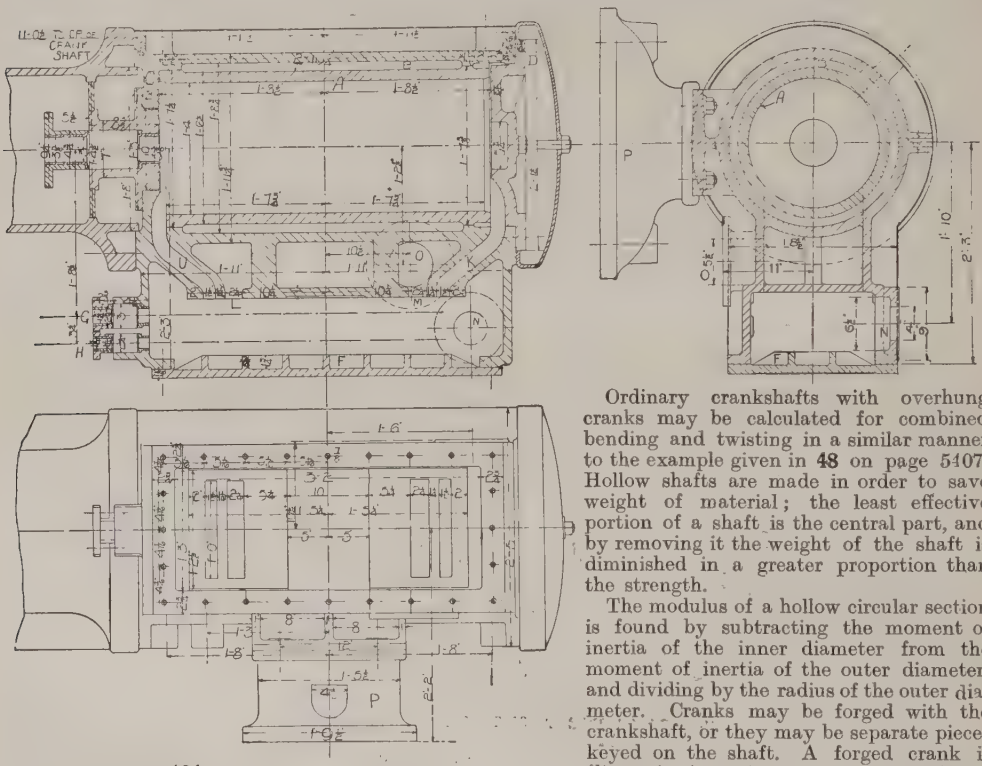
Let S = diameter of shaft in inches.
P = absolute boiler pressure.
C = length of crank in inches.
D = diameter of low-pressure cylinder.
d = diameter of high-pressure cylinder.
f = a factor depending upon angle of crank.

For compound condensing engines with cranks not overhung,

$$S = \sqrt[3]{\frac{C \times P \times D^2}{f\left(2 + \frac{D^2}{d^2}\right)}}$$

The values for f may be taken from this table.

Angle between cranks	90°	110°	120°	140°	160°	180°
Value for f ..	1047	904	855	788	751	740

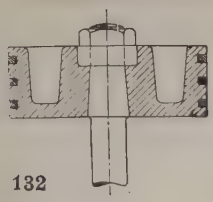


131. ENGINE CYLINDER

Ordinary crankshafts with overhung cranks may be calculated for combined bending and twisting in a similar manner to the example given in **48** on page 5407. Hollow shafts are made in order to save weight of material; the least effective portion of a shaft is the central part, and by removing it the weight of the shaft is diminished in a greater proportion than the strength.

The modulus of a hollow circular section is found by subtracting the moment of inertia of the inner diameter from the moment of inertia of the outer diameter, and dividing by the radius of the outer diameter. Cranks may be forged with the crankshaft, or they may be separate pieces keyed on the shaft. A forged crank is shown in **135**; it is generally machined all over, and the ends turned in the lathe about the centre, A. The diameter of the pin, B, is usually the same diameter as the shaft; the width, C, is one and a quarter times the shaft diameter, and the thickness, D, is three-quarter times the shaft diameter. The cranks and pin may be separate pieces, in which case the cranks are swelled out to fit over the shaft and over the pin; the thickness of metal allowed in the swelled parts should not be less than ·4 of the shaft diameter.

Cast-iron crank discs are made as **142**, the crank-pin is fitted in tightly, and the end riveted over; the metal is thickened up at the side opposite the pin for the purpose of balancing the connecting rod head.



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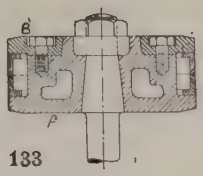

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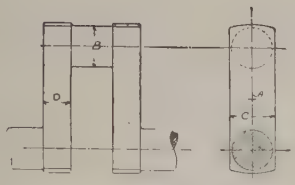

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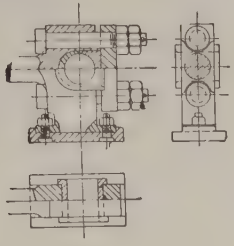

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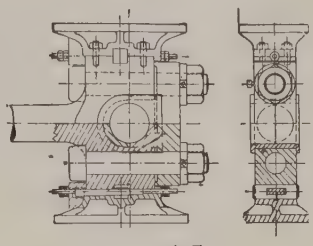

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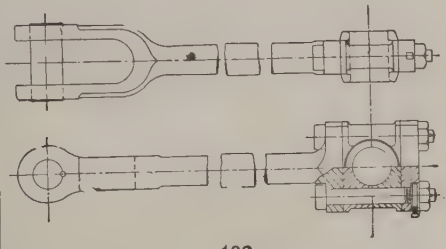

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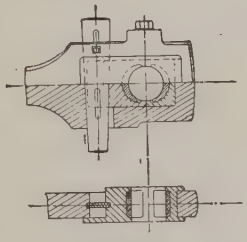

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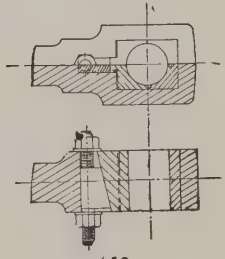

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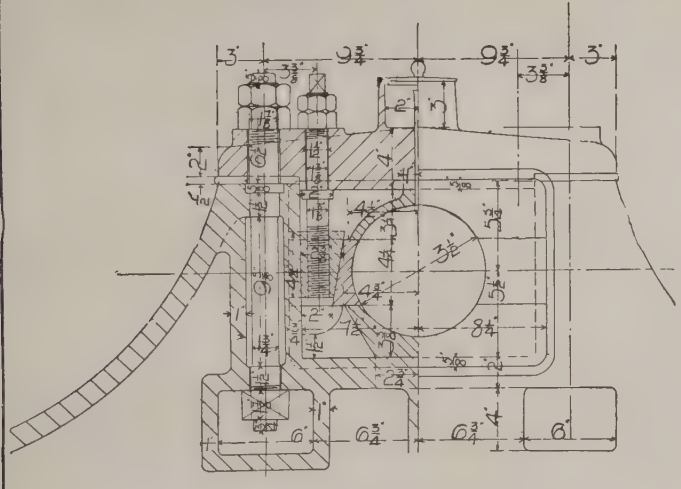

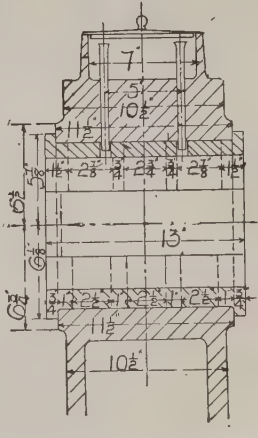

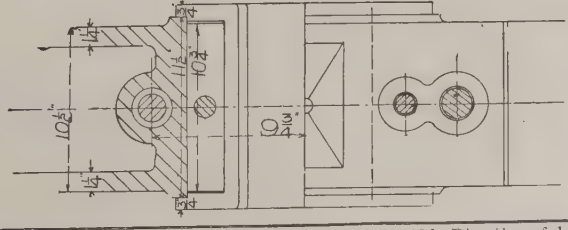

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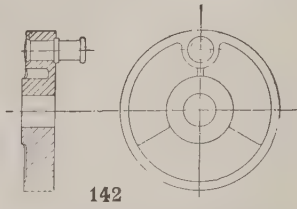


142

132. Piston with Ramsbottom rings **133.** Piston built up **134.** Direction of load on crosshead **135.** Forged double crank **136.** Single slipper crosshead **137.** Double slipper crosshead **138.** Connecting-rod **139.** Large end of connecting-rod **140.** Small end of connecting-rod **141.** Elevations and plan of main bearing **142.** Crank disc

Main Bearings. An example of an engine main bearing is given in **141**. The brass is in four parts, so as to permit adjustment all round the shaft. The top and bottom parts are adjusted in the usual way, but the side portions are set up by means of a taper block and screws, as shown; the drawing explains itself.

Flywheels. The theory of flywheels is discussed on page 2358 in this group. Fig. **145** shows an ordinary flywheel; the rim is solid and is arranged with pockets round the periphery; these pockets are used for starting the wheel from rest when the engine is on dead points. The appliance which effects the starting is termed a *barring gear*, and may range from a simple lever to a separate small engine. The arms of the wheel are oval, and they taper from the boss to the rim. The boss has wrought-iron rings shrunk on to give it increased strength.

A smaller flywheel is shown in **143**; the arms are rectangular in section, and cranks are cast with the boss; such a wheel would be used on a small pumping engine. The inside of the rim opposite the crank-pin is thickened up to balance the pump-rod head.

Eccentrics. Eccentrics are used to give reciprocating motion to the valve-rods on an engine; a common example is shown in **144**. The inner part, or sheave, A, is keyed to the shaft; the centre of the sheave does not coincide with the centre of the shaft; the distance apart, B, of the centres represents half a stroke of the strap, C, and the eccentric rod is bolted up to the end, D. Both strap and sheave are in halves for convenience of renewal, but the sheave is not always in halves; the straps must be made so on account of getting over the register, which keeps it sideways.

Valves. A simple D valve is shown in various positions of stroke in **147** to **150**; the stroke of the valve is due to the eccentric. In **147** the valve is just open to steam, the piston is at the beginning of its stroke, and the connecting rod and crank are in a horizontal line—that is, on dead centres. The exhaust port is nearly full open. In **148** the valve is full open to both exhaust and steam, the piston is is travelling along the cylinder, and the crank at 45°.

In **149** the valve is reversed by the eccentric, and has closed the steam-port, the piston is moving forward under the influence of the expanding steam, and the exhaust is partially closed; the crank is well over 90 deg. In **150** the exhaust is closed, and the valve is moving to open steam for the reversal of the piston stroke. There are many types of valves in use, but their duties are all identical—namely, to regulate the flow of steam and exhaust to and from the cylinder economically.

Pumps. An air-pump, together with two bilge-pumps, is shown in **146**. The air-pump is of brass, though not necessarily so, and the thickness of its walls is kept down to a minimum, as the metal is expensive. The piston is termed a *bucket*, and is fitted with non-return valves for lifting water; the top and bottom of the pump are fitted with separate plates carrying similar valves. The bilge-pumps are of heavier metal, as they have to pump against a head; they are used for pumping the bilge-water from steamships. The plunger displaces a volume of water equal to its bulk at each stroke. Both bilge-pumps and the air-pump are driven from a single crosshead, operated by the air-pump levers. The bilge-pump valves are simple in construction, and are fitted in the piping connected to the pumps.

In an engine fitted with a jet condenser the air-pump has to remove the condensed steam, the water used for condensing the steam, and the air which enters with the water. In a surface condensing engine the air-pump removes the condensed steam and any air which may enter the engine; the condensing water in such cases is dealt with by separate pumps, termed *circulating* pumps.

Size of Air-pump. The size of the air-pump for a condensing engine may be determined by the following rule:

$$\text{Volume of air-pump} = \frac{\text{Indicated h.p.}}{\text{revs. per min.}} \times \text{C.}$$

where C = 700 for single-acting and jet condenser,
C = 300 for single-acting and surface condenser,
C = 470 for double-acting horizontal pump and jet condenser.

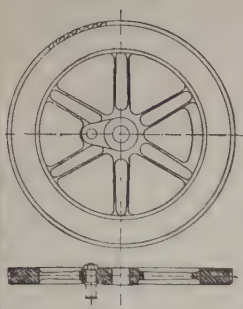
Another rule is to make the capacity of the air-pump one-twelfth of the capacity of the low-pressure cylinder. There are so many contingencies to be allowed for in the working of an air-pump that pure theory cannot be relied upon in the design. The action of the pump is not perfect, inasmuch as it does not remove at each stroke an amount of water, etc., equal to its capacity. Ordinary pumps are defective enough in this respect, but air-pumps, and particularly vertical ones, are very inefficient. The speed of the pump affects its efficiency to a great extent; the best results are obtained at a bucket-speed not exceeding 200 ft. per minute; many examples are, however, to be found running at as high a speed as 450 ft. per minute at a lower efficiency.

The limit of speed is that at which the water can follow the bucket, and so provide a full barrel for the next stroke, and this in turn depends upon the vacuum maintained. The pressure of the atmosphere is 14·7 lb. per square inch, and a good vacuum is 2 lb. per square inch; it is not possible to maintain a perfect vacuum in practice. The theoretical velocity of water under a pressure of 2 lb. per square inch is 1025 ft. per minute, but it would not do to speed the pump bucket accordingly. Allowance must be made for friction, for the inertia of the water, and for the presence of air and gases in the water; this can only be determined by practice; and the speed range of 200 ft. to 450 ft. per minute as given above is deduced therefrom.

Fouls. It will be noticed, upon examination of the sectional elevation of **146**, that one bucket valve is shown dotted at the upper end of the stroke, while the bucket itself is shown at the lower end of the stroke; there is an object in doing this, and one which must be ever present with the designer of moving machinery.

Wherever one part of a machine moves relatively to another part, it must be drawn in its extreme, and sometimes intermediate, positions in order to avoid fouls. All the various movements must be carefully plotted on paper beforehand in such a way as to ensure the complete and smooth working of the whole machine. It sometimes happens during manufacture that through an oversight in the drawing office a machine cannot complete a cycle of movements without a foul of some nature.

JOSEPH W. HORNER



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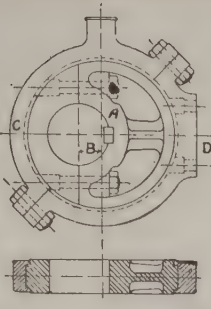

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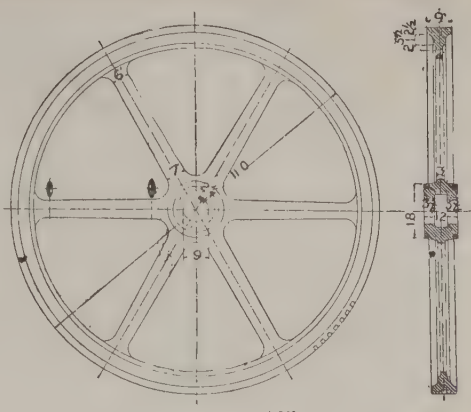

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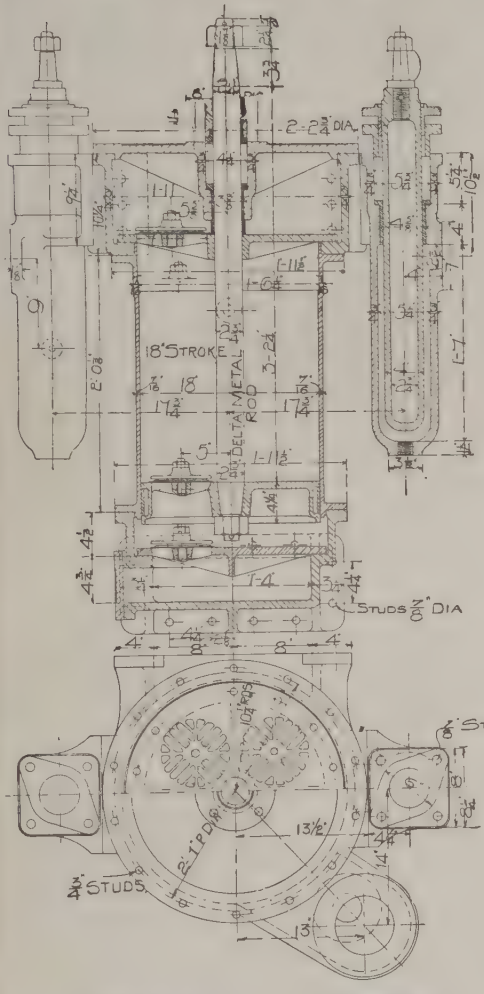
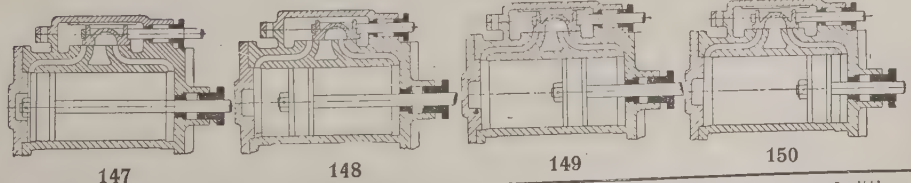


146



147 148 149 150

143. Pump flywheel **144.** Eccentric **145.** Engine flywheel **146.** Air and bilge pumps **147.** Valve admitting steam **148.** Valve full open for steam **149.** Valve closed for steam **150.** Valve closed for exhaust

The World's Petroleum Deposits and their Recent Development. Spouters. Oil Shales.

OILFIELDS OF THE WORLD

IN the brief account, which is all that can here be given, of the numerous oilfields of the world, the comparatively unimportant areas, supplying or partially supplying only local requirements, are necessarily ignored. Of those mentioned, the relative importance changes almost month by month with the discovery of new fields, the variations in activity of operation of those previously in work, and other causes too numerous to specify.

The Wells of the United States. Nearly every State in the Union rejoices in the possession of a greater or less extent of oil-bearing territory, the sole exceptions being some on the Atlantic coast, and some westward of the Great Lakes on the northern frontier. The several States, like the rest of the world, continually vary in the relative importance of their production of petroleum, and a purely geographical course will be the simplest to follow in a rapid sketch of the principal fields.

The Appalachian oilfields—comprising a great number of more or less independent "oil-pools," or centres of yield separated by barren areas—begin in Allegheny County, New York, and, traversing the western side of Pennsylvania and West Virginia, and portions of Kentucky and Tennessee, extend some 50 miles into Alabama, a range of about 700 miles. Throughout this length the lower portion of the Carboniferous system and the subjacent Devonian have yielded a large proportion of the American output of petroleum, though now largely depleted of oil. The great cities of Pittsburg and Allegheny at one time maintained their extensive metallurgical and kindred industries largely by means of the abundant gas present in the sands of the Catskill group at the base of the Carboniferous series, while the richest yield of oil is derived from the Chemung division of the Devonian system.

In Eastern Ohio the same rock-groups afford petroleum as in Pennsylvania, but in the interior of the State, and also in Kentucky and Tennessee, the yet lower Silurian series supplies large quantities of oil and gas. The oil, however, varies in quality from that of the higher rock-series, in containing a considerable amount of sulphur, and requiring special processes for its purification. The difference is probably due to the derivation of the Silurian limestone oil from animal remains, while the paraffin oil of the Devonian and Carboniferous sandstones appears to be of vegetable origin. In the Indiana and Illinois fields the Carboniferous, Devonian, and Silurian all supply petroleum in varying amounts. Missouri and Arkansas produce but little oil, which is of Carboniferous age. Beyond this, we find a rich oilfield in the lower Carboniferous rocks occupying the south-western parts of Kansas, and extending across Oklahoma and Indian Territory. The belt of these rocks continues across Texas to the Mexican frontier, but apparently in less productive condition, though this may be due not so much to its poverty as to neglect of testing operations, owing to the presence, further eastward in the State, of formidable rival fields in the Cretaceous and Tertiary rocks, where the additional advantage exists of being nearer to the coast of the Gulf of Mexico. Nearly every county in the eastern half of Texas is more or less petroliferous, and especially Hardin and Jefferson. These and others along the Gulf Coast comprise several independent oilfields. The coastal fields extend from Corpus Christi, Texas, into Louisiana, as far as the Atchafalaya branch of the Mississippi, and may eventually be found to range into Florida. In the West Indian Islands the petroliferous belt may be traced through Cuba, Hayti, Porto Rico, Barbados, and Trinidad, to the coast-fields of Venezuela and Colombia; while in the opposite direction it is more or less continuous from the Texas frontier throughout the Atlantic States of Mexico.

To the west of the great plains of Kansas and Nebraska rise the hills of Colorado, Utah, and Wyoming, with many oilfields of varying importance. These are mostly in Cretaceous and Tertiary rocks, but the Carboniferous, Triassic, and Jurassic systems afford minor yields in places. California has in recent years advanced rapidly to the premier position among the States in the production of petroleum, especially in the southern half of the State, including Santa Barbara, Ventura, Los Angeles, Fresno, and Kern Counties. The productive rocks are of Tertiary age.

On the southern coast of Alaska an oilfield of considerable size and promise has been in course of development for a few years in the Tertiary area eastward of the mouth of Copper River.

Mexico. One of the chief features of the development of the industry within recent years has been the extraordinarily rapid increase in the output of petroleum from the prolific oilfields of Mexico, that country having rapidly advanced to the rank of third in importance of the sources of the world's supplies.

British America. The oilfields of Western Ontario were exploited a few years after the beginning of the commercial development of the petroleum industry in Pennsylvania. The productive rock here is the Corniferous limestone, a member of the Devonian series, not petroliferous to any notable extent in the United States. In the western provinces, Alberta, Athabasca, and Mackenzie, the Cretaceous rocks give promise of a large output of petroleum when due means of communication and transport are available, but the region cannot be classed among productive oilfields at present. There are some petroliferous deposits of Lower Silurian age on the eastern coast of Quebec (Gaspé peninsula) and also on the western shores of Newfoundland.

Trinidad. Reference has been made above to Trinidad as constituting a link in the chain of oil deposits fringing the Gulf of Mexico. The Pitch Lake, one of the most popular "sights" of the island, drew more attention from travellers than from men of commerce till within the last thirty years, during which the asphalt it yields has been more and more extensively raised, and recently a

beginning has been made in the commercial exploitation of highly promising oilfields in various parts of the southern half of the island. Like all the petroleum of the Caribbean area, the oil is of Tertiary age.

Russia—The Oil-wells of Baku. The petroleum industry of Baku is probably of as great antiquity as that of Japan, to be described presently. It is mentioned by many ancient and mediæval writers, the discharge of oil-gas in the ancient fire-temple of the Guebers at Surakh ni having been the object of perennial pilgrimages from all parts of the East. The Apscheron peninsula, from the natural springs in a few square miles of which the Orient world was long supplied with petroleum, was Persian territory prior to 1723, and is mentioned, under various names, as part of that country by the earlier writers. By degrees other natural outflows were noticed in various parts of the Caucasus, but there was no systematic production from wells till 1806, when a monopoly of the trade was granted to a merchant of the name of Mirzoeff. It was not, however, till the abolition of this monopoly, in 1872, that extensive and rapid development set in. As the Baku field was the first to afford enormous volumes of oil from "spouters" or "fountains," the following account is quoted from Marvin of the Droojba fountain, which in 1883 discharged 1,600,000 to 2,000,000 gallons daily, flowing for nearly four months before the engineers succeeded in capping it—that is, closing the lining pipe:

"The fountain was a splendid spectacle—it was the largest ever known in Baku. When the first outburst took place, the oil knocked off the roof and part of the sides of the derrick, but there was a beam left at the top, against which the oil burst with a roar in its upward course, and which served in a measure to check its velocity. The derrick itself was 70 ft. high, and the oil and the sand, after bursting through the roof and sides, flowed fully three times higher, forming a greyish-black fountain, the column clearly defined on the southern side, but merging in a cloud of spray 30 yds. broad on the other. A strong southerly wind enabled us to approach within a few yards of the crater on the former side, and to look down into the sandy basin formed round about the bottom of the derrick, where the oil was bubbling round the stalk of the oil-shoot like a geyser. The diameter of the tube up which the oil was rushing was 10 in. On issuing from this the fountain formed a clearly defined stem about 18 in. thick, and shot up to the top of the derrick, where, in striking against the beam, which was already worn half through by the friction, it got broadened out a little. Thence continuing its course, more than 200 ft. high, it curled over and fell in a dense cloud to the ground on the north side, forming a sandbank, over which the olive-coloured oil ran in innumerable channels towards the lakes of petroleum that had been formed on the surrounding estates. Now and again the sand flowing up with the oil would obstruct the pipe, or a stone would clog the course; the the column would sink for a few seconds lower than 200 ft., to rise directly afterwards with a burst and a roar to 300.

A River of Oil. "Some idea of the mass of matter thrown up from the well could be formed [this account continues] by a glance at the damage done on the south side in twenty-four hours, a vast shoal of sand having been formed, which had buried to the roof some magazines and shops, and had blocked to the height of 6 or 7 ft. all the neighbouring derricks within a distance of 50 yds. Some of the sand and oil had been carried by the wind nearly 100 yds. from the fountain. . . . Standing on the top of the sand-shoal, we could see where the oil, after flowing through a score of channels from the ooze, formed in the distance, on lower ground, a whole series of oil-lakes, some broad enough and deep enough to float a boat in. Beyond this the oil could be seen flowing away in a broad chanel towards the sea."

Far larger spouters, less graphically described, were subsequently produced, one in 1893 exceeding 48,000,000 gallons daily. Fairly rich fields extend through the Daghestan, Terek, and Kuban territories, on the north flank of the Caucasus, and the province of Tiflis on the south, the Gronzi district (Terek) being especially rich. The Taman and Kertch peninsulas, between the Sea of Azoff and the Black Sea, constitute the western end of this prolific belt, which on the further side of the Caspian Sea reaches far into Turkestan. The age of the productive rocks ranges from Oligocene to Miocene in the European portion of the chain, while in the Uralsk and Ferghana regions the Cretaceous series is also contributory.

Austria and Rumania. In these countries a practically continuous oilfield extends along the outer flanks of the Carpathian Mountains and the Transylvanian Alps, affording rich yields in Galicia and Rumania, while there are indications, as yet but little developed, on the inner Hungarian side of this long curve. The minor divisions of the Galician area have undergone many changes in relative commercial importance, the Sloboda-Rungurska, Krosno, Gorlice, and Schodnica districts having been at different times the leading centres of production, now quite eclipsed by that of Borys-law-Tustanowice. Boryslaw was long noted for its rich mines of ozokerite, with little suspicion of the wealth of petroleum that lay at a greater depth. The ozokerite occurs in the marls of the Miocene age, which it traverses as plastic veins. The oil is found in the subjacent Oligocene conglomerate, to which wells of great depth have been carried. The Eocene sandstones largely contributed to the earlier production of oil in Galicia, and the Neocomian series has also been found fairly petroliferous in the western districts. In Moldavian Rumania the Eocene is again the productive series, while in the Wallachian fields the Miocene and Pliocene groups afford copious supplies, widely developed.

Germany and Italy. The chief oilfields of Germany are in Hanover and Alsace. In the latter province oil has been raised for some 400 years past from the wells of Pechelbronn, Ohlungen, and intermedaite points, the Lower Oligocene marls being the source. The principal production of Hanover centres around Oelheim and Steinförde, various secondary rocks, chiefly Triassic and Neocomian, being the source of supply. The wide plains of the Luneburger Heide, covered over by more recent deposits, are believed to conceal valuable stores of petroleum in the deep-seated members of the older rock-series. The chalk of Holle, in Holstein, is reported to be charged with petroleum.

Oil was raised and used by the Romans from wells at Agrigentum (now Girgenti), in Sicily, more than 2000 years ago. That of Miano, Parma, is mentioned A.D. 1400. At present the Italian industry is confined to production for local use, and is limited to the Emilian provinces (Piacenza,

Parma, Modena, and Bologna), the Abruzzi (Tocco and Manopello), and Campania (San Giovanni Incarico). The sources are Tertiary age, mostly Eocene, but newer in some cases.

Northern Africa and Western Asia. In Algeria, the oilfields of the province of Oran occur in Miocene rocks on both sides of the Cheliff valley, between Orleansville and Mostaganem. Approximately, the same age may be assigned to the deposits on the Egyptian shore of the Red Sea, at the mouth of the Gulf of Suez, the Arabic name of the hill, Jebel Zeit, and the Roman name, Mons Petrolius, both connoting the occurrence of mineral oil. In Syria, the oil and asphalt of the Dead Sea were known long before the petty "kings" of the Vale of Siddim met their fate in the "slime-pits" there (Gen. xiv. 10), and supplied the bitumen for embalming the countless mummies, human and other, of Egypt, *mum* being the Coptic for bitumen. In Mesopotamia, the oil-springs of Hit, on the Euphrates, furnished the "slime" cementing the bricks of the Tower of Babel and other vast erections of antiquity, the ruins of which still provide pitch for the gophers (wicker boats payed with asphalt) on the Euphrates and Tigris. In Persia, many highly productive wells have already been drilled, but a great extent of oil-bearing territory is yet awaiting development, from the Turkish frontier above Bagdad, to Bunder Abbas, on the Persian Gulf.

Assam and Burma. Profitable operations are in progress at but one point in the long belt of country constituting the foothills on the southern side of the Brahmaputra valley, at many points of which occur evidences of petroleum. The field in work is at Digboi, a few miles north of the present terminus of the Makum branch of the Assam railway system. The productive series is a division of the Miocene, but some petroleum has been found in the Eocene also.

The oil industry of Burma dates from more than a century back, having been in vigorous development in 1795. The chief source then, as now, was the Yenangyaung district, some 275 miles northward of Rangoon. Parts of this, and of the Yenangyat field, 50 miles farther north, are crowded with oil-pits sunk by natives to depths ranging to more than 300 ft., whence the oil raised is by bailing. Within recent years, Western drilling methods have been introduced, and far greater depths obtained, resulting in many excellent producers, while fresh areas, within which oil is accessible by the drill, though not by the spade, have been brought to notice by special exploration for their discovery. Traces of petroleum occur in the Eocene rocks, but the Lower Miocene alone yields a supply of commercial value, and this division is exposed at frequent intervals over an area of many hundred square miles. In Cheduba, Ramri, the Baranga, and other islands off the Arakan coast, intermittent attempts have been made, with poor success, to collect the oil there ejected by numerous mud-volcanoes from the uptilted and shattered rocks, also of Tertiary age.

The Eastern Archipelago and Japan. In the islands of Sumatra, Java, and Borneo, petroleum is raised at many points, from beds of presumably the same Upper Tertiary age as those of Assam and Burma. On the north-eastern coast of Sumatra, the Langkat fields range to Edi, in the Atchin province, and a large area in Palembang extends up the Musi to 100 miles westward and 80 miles southward of the capital. With the further opening up of the east coast, it is probable that other fields will be found in the intervening regions. In Java, a long stretch of country from Samargan to Surabaya and Madura has been found productive, and the traces detected in many other provinces may eventually extend the industry over a large part of the island. In Borneo, again, a belt of petroliferous land appears to occupy the northern coast from Sarawak to beyond Labuan, and rich fields are in work on the eastern coast in Tidung and Kutei provinces. The traces of oil alleged to occur on Celebes, Ceram, and New Guinea may be mentioned as indicative of the existence of the same productive series at those points, but in problematical extent. The Philippine Islands are reported as petroliferous at many points, and in the Portuguese division of Timor petroleum has been discovered on its southern coast.

Petroleum occurs in Japan throughout the northern islands of Hokkaido or Yezo, and large fields have been worked for many centuries in Nippon, especially on the western coast. The oilfields of the north-east coast of Sakhalin, not hitherto brought into use, are beyond the Japanese frontier in that island.

South America. As was mentioned above in connection with the West Indian Islands, rich asphalt deposits, with probably stores of unaltered petroleum beneath them, protected from escape or evaporation by the impervious cover of asphalt, occupy large areas of great promise in Venezuela and Colombia. The north-western coast of Peru, from the border of Ecuador down to Point Aguja, a distance of about 180 miles, constitutes an important oilfield. As in the smaller field of Santa Elena, in Ecuador, the productive series is of Lower Miocene age, rising in anticlinal flexures through the general covering of Upper Miocene and Pliocene beds. The inland margin is defined by the spurs of the Andes, consisting of various older rocks. In the Argentine provinces of Salta and Jujuy, and the adjacent regions of Bolivia, the Neocomian rocks are charged with petroleum over wide areas.

Oil-shales. Besides the reservoirs of petroleum and sheets of asphalt distributed, as we have seen, over every part of the world, and in rocks of nearly every geological period, there are deposits of oil-shale and lignitic coal which, while not containing any ready-formed oil, afford by distillation a fair yield of various hydrocarbons akin to or identical with the natural petroleums. A wide area of such shales occurs in the Lothians of Scotland, westward of Edinburgh, in the lower part of the Carboniferous series; and the coast of Dorsetshire possesses a belt of oil-shale of Upper Jurassic age. In France, the upper part of the Carboniferous series has valuable deposits of shale at Autun and Buxière; and in Southern Spain, the Lower Jurassic shales are practically unworked. In Prussian Saxony, between Halle, Leipzic, and Zeitz-on-Elster, is a large area of Oligocene beds with oil-lignites and shales, extensively worked for paraffin and lubricating oils. In Serbia, the Lower Miocene oil-shales occupy important areas near Alexinatz and in the Kolubara valley. In South Africa, the Portuguese territory north of Delagoa Bay is reported to possess a coast belt of Cretaceous shales of considerable width and good yield. In New South Wales, the Carboniferous series affords valuable oil-shales mined over a wide area. In New Zealand, oil-shales of Tertiary age occur in Auckland and Otago. Lastly, along the coast of Brazil from the mouth of the Amazon, for more than 1200 miles to the south, deposits of oil-shale of Eocene age occur in recesses between the spurs of the ancient crystalline rocks.

BOVERTON REDWOOD

Ratios of 15° and 75°. Formulæ for Sum and Difference of Two Sines or Cosines. Multiple Angles. Logarithms.

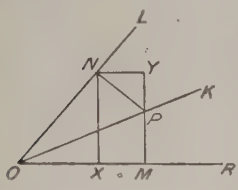
COMPOUND ANGLES

22. A. To prove that

$\sin (A - B) = \sin A \cdot \cos B - \cos A \cdot \sin B$

and

$\cos (A - B) = \cos A \cdot \cos B + \sin A \cdot \sin B.$



Let ROL be the angle A, and LOK the angle B. Then ROK is the angle (A − B). Making the same construction as before, we have ∠s PMO, PNO right ∠s. ∴ a ⊙ on OP as diameter passes through M and N. Hence ∠YPN is the supplement of ∠NPM, and ∴ is equal to ∠MON (*Prop.* 41), *i.e.*, to ∠A. Then

$$\begin{aligned}\sin (A - B) &= \frac{MP}{OP} = \frac{XN - PY}{OP} = \frac{XN}{OP} - \frac{PY}{OP} \\ &= \frac{XN}{ON} \cdot \frac{ON}{OP} - \frac{PY}{PN} \cdot \frac{PN}{OP} \\ &= \sin ROL \cdot \cos LOK - \cos YPN \cdot \sin LOK \\ &= \sin A \cdot \cos B - \cos A \cdot \sin B.\end{aligned}$$

Again, $\cos (A - B)$

$$\begin{aligned}&= \frac{OM}{OP} = \frac{OX + NY}{OP} = \frac{OX}{OP} + \frac{NY}{OP} \\ &= \frac{OX}{ON} \cdot \frac{ON}{OP} + \frac{NY}{PN} \cdot \frac{PN}{OP} \\ &= \cos ROL \cdot \cos LOK + \sin YPN \cdot \sin LOK \\ &= \cos A \cdot \cos B + \sin A \cdot \sin B.\end{aligned}$$

In the above proofs we have only considered the cases in which the ∠s A, B and (A + B) are each less than a right angle. It is left as an exercise to the student to draw the figures and modify the proofs for other values of the angles.

23. Ratios of 15° and 75°. The results of the last article enable us to find the ratios of 15° and 75°.

EXAMPLE. Find the value of tan 75°.

$$\tan 75° = \tan (45° + 30°) = \frac{\sin (45° + 30°)}{\cos (45° + 30°)}$$

$$= \frac{\sin 45° \cos 30° + \cos 45° \cdot \sin 30°}{\cos 45° \cos 30° - \sin 45° \sin 30°}$$

$$= \frac{\cos 30° + \sin 30°}{\cos 30° - \sin 30°}$$

[Cancelling numerator and denominator by $\frac{1}{\sqrt{2}}$, which is the value of both sin 45° and cos 45°]

$$= \frac{\frac{\sqrt{3}}{2} + \frac{1}{2}}{\frac{\sqrt{3}}{2} - \frac{1}{2}} = \frac{\sqrt{3}+1}{\sqrt{3}-1} = \frac{(\sqrt{3}+1)^2}{3-1} = \frac{4+2\sqrt{3}}{2}$$

$$= 2 + \sqrt{3}.$$

The other ratios of 75° can be found in a similar way. In the case of 15°, we use the fact that 15° = 45° − 30°.

24. Formulæ for tan (A ± B). We have

$$\begin{aligned}\tan (A+B) &= \frac{\sin (A+B)}{\cos (A+B)} = \frac{\sin A \cos B + \cos A \sin B}{\cos A \cos B - \sin A \sin B} \\ &= \frac{\frac{\sin A \cdot \cos B}{\cos A \cdot \cos B} + \frac{\cos A \cdot \sin B}{\cos A \cdot \cos B}}{\frac{\cos A \cdot \cos B}{\cos A \cdot \cos B} - \frac{\sin A \cdot \sin B}{\cos A \cdot \cos B}} \\ &= \frac{\tan A + \tan B}{1 - \tan A \cdot \tan B}.\end{aligned}$$

Similarly, we get

$$\tan (A - B) = \frac{\tan A - \tan B}{1 + \tan A \cdot \tan B}.$$

By the same method the student can prove that

$$\cot (A + B) = \frac{\cot A \cdot \cot B - 1}{\cot A + \cot B},$$

and

$$\cot (A - B) = \frac{\cot A \cdot \cot B + 1}{\cot B - \cot A}.$$

25. The "S, T" Formulæ. We have already proved that

$\sin (A + B) = \sin A \cdot \cos B + \cos A \cdot \sin B,$
$\sin (A - B) = \sin A \cdot \cos B - \cos A \cdot \sin B,$
$\cos (A + B) = \cos A \cdot \cos B - \sin A \cdot \sin B,$
$\cos (A - B) = \cos A \cdot \cos B + \sin A \cdot \sin B.$

By adding and subtracting the first pair of results we get

$$\left.\begin{aligned}\sin (A+B) + \sin (A-B) &= 2 \sin A \cdot \cos B \\ \sin (A+B) - \sin (A-B) &= 2 \cos A \cdot \sin B\end{aligned}\right\} \quad \ldots (1)$$

Similarly, from the second pair we get

$$\left.\begin{aligned}\cos (A+B) + \cos (A-B) &= 2 \cos A \cdot \cos B \\ \cos (A-B) - \cos (A+B) &= 2 \sin A \cdot \sin B\end{aligned}\right\} \quad \ldots (2)$$

Let A + B = S, and A − B = T. By solving these equations we find $A = \frac{S+T}{2}$ and $B = \frac{S-T}{2}$.

Substitute these values of A and B in (1) and (2). Then

$$\sin S + \sin T = 2 \sin \frac{S+T}{2} \cdot \cos \frac{S-T}{2},$$

$$\sin S - \sin T = 2 \cos \frac{S+T}{2} \cdot \sin \frac{S-T}{2},$$

$$\cos S + \cos T = 2 \cos \frac{S+T}{2} \cdot \cos \frac{S-T}{2},$$

$$\cos T - \cos S = 2 \sin \frac{S+T}{2} \cdot \sin \frac{S-T}{2}.$$

These results should be remembered *in words*, thus

(i.) *The sum of the sines of two angles equals twice the sine of half their sum, times the cosine of half their difference.*

(ii.) *The difference of the sines of two angles equals twice the cosine of half their sum, times the sine of half their difference.*

(iii.) *The sum of the cosines of two angles equals twice the cosine of half their sum, times the cosine of half their difference.*

(iv.) *The difference of the cosines of two angles* [the cosine of the *less*, minus the cosine of the *greater*] *equals twice the sine of half their sum, times the sine of half their difference.*

The student must also be able to make a ready use of the results (1) and (2); *i.e.*, he must remember that the product of a sine and cosine can be expressed as the sum of two sines, and so on.

EXAMPLE.

$$\cos\frac{3A}{2}\cdot\cos\frac{A}{2}$$
$$=\frac{1}{2}\left\{\cos\left(\frac{3A}{2}+\frac{A}{2}\right)+\cos\left(\frac{3A}{2}-\frac{A}{2}\right)\right\}$$
$$=\frac{1}{2}\{\cos 2A+\cos A\}.$$

26. Trigonometrical Ratios of Multiple Angles.

By putting $B = A$ in the formula

$$\sin(A+B)=\sin A\cdot\cos B+\cos A\cdot\sin B,$$

we get

$$\sin(A+A)=\sin A\cdot\cos A+\cos A\cdot\sin A;$$

i.e.,
$$\sin 2A = 2\sin A\cdot\cos A. \quad . \quad . \quad . \quad . \quad (1)$$

Again, from

$$\cos(A+B)=\cos A\cdot\cos B-\sin A\cdot\sin B,$$

we get

$$\cos(A+A)=\cos A\cdot\cos A-\sin A\cdot\sin A;$$

i.e.,
$$\cos 2A=\cos^2A-\sin^2A. \quad . \quad . \quad . \quad . \quad (2)$$

Since $1=\cos^2A+\sin^2A$,

it follows that

$$1+\cos 2A = 2\cos^2A$$

and
$$1-\cos 2A = 2\sin^2A,$$

or
$$\left.\begin{aligned}\cos 2A &= 2\cos^2A-1\\ \cos 2A &= 1-2\sin^2A\end{aligned}\right\}. \quad . \quad . \quad . \quad . \quad (3)$$

Also, from

$$\tan(A+B)=\frac{\tan A+\tan B}{1-\tan A\cdot\tan B},$$

we get

$$\tan(A+A)=\frac{\tan A+\tan A}{1-\tan A\cdot\tan A};$$

i.e.,
$$\tan 2A=\frac{2\tan A}{1-\tan^2A}. \quad . \quad . \quad . \quad (4)$$

These four formulæ are important, and must be remembered. They are, of course, true for *all* values of A, so that it is just as useful to know the results obtained by putting A instead of 2A. Thus we have $\sin A = 2\sin\frac{A}{2}\cdot\cos\frac{A}{2}$, and so on.

27. Sin 3A in terms of sin A.

$\sin 3A$
$= \sin(2A+A)$
$= \sin 2A\cdot\cos A+\cos 2A\cdot\sin A$
$= (2\sin A\cdot\cos A)\cdot\cos A+(1-2\sin^2A)\cdot\sin A$
$= 2\sin A\cdot\cos^2A+\sin A-2\sin^3A$
$= 2\sin A\cdot(1-\sin^2A)+\sin A-2\sin^3A$
$= 2\sin A-2\sin^3A+\sin A-2\sin^3A$
$= 3\sin A-4\sin^3A.$

In a similar way we obtain

$$\cos 3A = 4\cos^3A-3\cos A.$$

LOGARITHMS

28. By algebra we know that

(i.) The index of the *product* of two powers of the same quantity is obtained by *adding* the indices of the powers.

(ii.) The index of a *quotient* is obtained by *subtracting* the indices of the powers.

(iii.) The index of a *power* or a *root* is obtained by *multiplying* or *dividing* the indices.

These facts are made use of to shorten arithmetical calculations. A power of the number 10 can be found which is practically equal to any given number. For example, 2 is approximately $10^{\cdot30103}$. The number 10 thus used is called the *base*; the index ·30103 is called the *logarithm* of 2 to the base 10. Hence,

DEFINITION. The *logarithm* of a number to a given base is the *index* of the power of the base which is equal to the given number.

Logarithms to the base 10 are, in general, incommensurable numbers. They have been calculated to seven significant figures, for all numbers from 1 to 100,000.

$\text{Log}_{10}2 = \cdot30103$, and $10^{\cdot30103}=2$, are different ways of stating the same fact.

29. From the index laws of Algebra we have

(i.) The logarithm of the *product* of two numbers is equal to the *sum* of the logarithms of the numbers.

(ii.) The logarithm of the *quotient* of two numbers is the logarithm of the dividend *minus* the logarithm of the divisor.

(iii.) The logarithm of a number raised to the *power p* is *p times* the logarithm of the number.

30. Since $10^0 = 1$, *the logarithm of* 1 is 0. Also, since $10 = 10^1$ and $100 = 10^2$, the logarithm of a number between 1 and 10 lies between 0 and 1, and that of a number between 10 and 100 lies between 1 and 2, and so on. Thus, *the logarithm of a number greater than* 1 *is positive.*

Again,
$$\cdot1=\frac{1}{10}=10^{-1},$$
$$\cdot01=\frac{1}{100}=10^{-2},$$

and so on, so that *the logarithm of a positive number less than* 1 *is negative.*

It is clear that the logarithm of a number between 1 and 10 is a positive decimal fraction; the logarithm of a number between 10 and 100 is equal to 1 + a decimal fraction, and so on.

Also, the logarithm of a number between 1 and ·1, *i.e.*, between 10^0 and 10^{-1}, lies between 0 and −1, and is therefore a negative decimal fraction. This *is equivalent to* $-1+$ *a positive decimal fraction.* Similarly, we see that the logarithm of a number between ·1 and ·01 can be written in the form $-2+$ a positive decimal.

H. J. ALLPORT

Economic Regions of the Russian Empire. The Siberian Railway. Rumania. Bulgaria. Serbia. Scandinavia. Austria-Hungary and the Mediterranean Nations.

THE TRADE OF EUROPE

We now turn to those European lands which are still in an early stage of industrial development and international trade on a large scale. Russia is by far the largest of these, and consequently possesses far the greatest potentialities. It is the greatest continuous land empire in the world, with an area of 8,000,000 square miles, containing a population of over 140,000,000 people [see GEOGRAPHY, pages 2397 and 2132-5]. In position and products it may be compared with Canada, but it is two and a half times as large, and its population is twenty times as great. It differs from its Canadian prototype in its western or European portion, and in Transcaucasia, Transcaspia, and Turan it exhibits a type markedly unlike anything in Canada.

The Four Zones of Russia. The four characteristic zones of tundra, forest or taiga, steppe, and desert have already been described. Except on its arctic and forest margins, both of which produce furs, the vast barren region of *tundra* is as yet economically valueless. Gold, however, is abundant in the north-eastern portion of Arctic Russian Asia, and, as in the corresponding Yukon region of Canada, will probably lead to a considerable development of mining enterprise.

The *taiga*, or forest zone, is already exploited to some extent for timber, wood-pulp, and other forest produce. In the main, however, it is a vast undeveloped asset. Wood is used for domestic purposes, as fuel for locomotives, and to feed the smelting furnaces of the Ural mining district.

The Mineral Wealth of the Forest Zone. The mineral wealth of this zone is considerable. It is greatest in the province of Perm, where it has long been exploited. Gold (in the Tura and Tagil valleys), platinum (now the most valuable industrial metal in the world), lead, copper, and tin are the chief metals, and Perm, Yekaterinburg (iron mines), Nizhni Tagilskyi (copper and platinum) are the most important mining centres. Magnetic iron ore is found in Finland, where granite quarries and the deposits of kaolin clay are beginning to be utilised by one of the most intelligent populations in Europe. Other mineral centres in the forest zone, which extends right across European Russia and far across Asiatic Russia, are the Altai Highlands (gold and silver), and the eastern mountains of Transbaikalia and Amuria (gold and tin). The Siberian graphite mines at Alibert are the most important in the world. Coal is now mined in the Southern Shenka district, between Tomsk and Maryinsk, in the Kirghiz steppe (where copper is also found), near Irkutsk, in the Southern Usuri region, near Vladivostok, and in Sakhalin.

In European Russia agriculture is possible, and has long been carried on in the numerous forest clearings. Rye and hemp are the chief crops cultivated, especially in the west in the Baltic provinces, whence most of the hemp supply of Europe is obtained.

Industries in this region, outside the metal smelting already mentioned, are developing around the coalfields of Poland, where Warsaw and Lodz are great cotton centres [see page 2134], and in the Moscow district, the latter using coal from the Oka coalfield round Tula. Moscow, Tver, Yaroslav, and Ivanovo (the latter known as the Russian Manchester) manufacture the raw cotton brought from the irrigated oases of Russian Central Asia. To a smaller extent, manufactures are also important at Petrograd and Narva.

A Stock-raising and Wheat-growing Region. The *steppe*, in its primitive economic condition, is a stock-raising region. The climate of the whole region is dry, but in the western part, which has the least scanty rainfall, the fertile black soil, *chernozoim*, is very fertile when cropped. Wheat is largely grown for export, while the cheaper rye supplies the food of the farming population. This may be compared with the similar conditions in India, where millet is the native food, and wheat is grown only for the European market. In both cases this recent development has been made possible by modern facilities of transport, the great magician of the modern world.

The *wheat* of this zone is a very important item in the world's supply. It is carried to the ports of the Black Sea (Ochakof, Odessa, Kherson, Taganrog, Rostof, and others) for export. For reasons explained in the case of Canada, milling is growing in importance at such centres as Odessa, where macaroni is manufactured.

The coal, iron, and manufacturing industries, though only of recent origin, are becoming firmly established in the steppe zone. Coal is mined in the Donets basin, and supplies the linen, tobacco, soap, and sugar manufactures of Kharkof. It is also used to smelt the red hæmatite and specular iron ores of Krovoi Rog, some hundred miles north of Kherson. Kief, on the margin between forest and steppe, manufactures linen and sugar from locally grown flax and beet.

In the irrigated lands of the *desert* zone enormous attention is being paid to the cultivation of cotton, which is sent to the cotton mills of Moscow and other textile centres of the Oka coalfield [see above]. The oil industry has been described on page 2398.

The Value of the Great Siberian Railway. Internal communications are improving year by year. The construction of the great transcontinental line of the Siberian Railway may be compared with the construction of the Canadian Pacific line. The first great step of providing through communication between the extreme east and west of a vast dominion having been achieved, Russia, like Canada, is now pushing on the work of spreading a network of branch lines into the unbroken lands on either side, and is linking up the Siberian line with the Central Asian lines. The examples of the United States and Canada leave no reason to doubt that this will be followed by a rapid extension of settlement—in this case, eastwards—and by the rapid utilisation of what is still, for the most part, an undeveloped asset, though of enormous potential richness.

Russian Exports. The Russian exports are even more difficult to analyse than those of the United States. Russia carries on a Baltic, a Black

Sea, a small Caspian, and a considerable Pacific trade. It has also a large overland trade, especially with the Central European Powers, and with its neighbours in Asia. Statistics distinguish between trade which crosses the European frontier, including the Caucasus, trade with Finland, and trade which goes across the Asiatic frontier. The figures are given in millions of roubles—1,000,000 roubles are worth rather more than £105,000.

Year	Trade across European frontier and Black Sea frontier of Caucasus	Trade with Finland	Trade across Asiatic frontier	Total
1905	954·4	38·3	54·3	1047·0
1910	1228·8	42·8	177·5	1449·1
1913	1365·5	55·3	162·4	1583·2

Excluding trade across the Asiatic frontiers, the following are the exports for 1913, the last year for which complete figures are available.

Class of export	Value in millions of roubles	Percentage
Articles of food	807·2	56·9
Raw and partly manufactured goods	550·2	38·7
Animals	32·9	2·3
Manufactured goods ..	30·4	2·1
Total	1420·7	100·0

These figures may be compared with those for Canada, with which they present a general similarity, though animals and manufactured goods bulk larger in Canada than in Russian exports. Of the articles of food exported from Russia, wheat is much the most considerable item. The principal raw and half-manufactured goods are timber and wooden goods from the forest zone. Cotton goods and flax from the agricultural zone, naphtha from the oil districts, to the value of 40·8 million roubles, and sugar to the value of over 20·4 million roubles, are the chief exports across the Asiatic frontier.

Imports. Taking the same classification of commodities as for the exports, the following were the imports into Russia in the same year, 1913.

Class of import	Value in millions of roubles	Percentage
Articles of food	163·0	13·3
Raw and partly manufactured goods	600·9	49·3
Animals	3·0	0·2
Manufactured goods ..	453·4	37·2
Total	1220·3	100·0

In the initial group, fish is first in value, closely followed by tea, and then by wine and spirits, among the foods. Raw cotton is by far the most important import, accounting for about one-tenth of the total value of the imports. Raw metals, coal, wool, and gums and resins are the next in order of value among the raw and partly manufactured goods. Machinery, metal goods, and textiles are the principal manufactured articles imported. Compare, again, with Canada.

Across the Asiatic frontier the imports are tea from China, but in diminishing quantities; rice (7·0 million roubles) from Persia, and raw cotton (13·8 million roubles) from Russian Central Asia, the latter in increasing quantities.

Countries with which Russia Trades. As might be expected, the German Empire has hitherto been Russia's best customer, the trade passing both overland and by the Baltic. The United Kingdom is second, sending in coals and manufactured goods in exchange for timber, hemp, flax, and some cereals, through the Baltic ports, and receiving large quantities of cereals through the Black Sea ports.

The following table indicate the value of Russia's trade with some of her most important customers.

Country	Imports from	Exports to	Total
	Millions of roubles	Millions of roubles	Millions of roubles
Germany	642·7	452·6	1095·3
United Kingdom ..	170·3	266·8	437·1
Netherlands	21·5	177·4	198·9
France	56·0	100·8	156·8
Finland	50·9	55·2	106·1
Austria-Hungary.	34·6	65·2	99·8
Italy	16·7	73·6	90·3
United States ..	74·1	14·1	88·2
Belgium	8·6	64·6	73·2

The distribution between the imports and exports in the case of the United States is accounted for by the large imports to Russia of raw cotton. To Belgium grain and flax are exported.

The Scandinavian Lands. Sweden and Denmark broadly resemble the other Baltic lands, Western Russia and Northern Germany. They consist of morainic lake-lands, interspersed with peat bogs. Forests are numerous, and timber, joinery, wood-pulp, and resins are among the exports. Agriculture is carried on in the clearings of Southern Sweden, and dairy farming (butter, cheese, eggs, bacon) is a staple industry of Denmark. Sweden possesses rich deposits of iron ore at Dannemora and Gellivara [see page 1343].

Sweden. Nearly half the population (45 per cent.) of Sweden live by farming, a quarter by manufactures, trade, and transport, and 6 per cent. by mining. The manufacturing classes are engaged chiefly in iron, steel, and engineering works, textile and shoe factories, sugar mills and sugar refineries, breweries, flour mills, and tobacco factories. The trade of Sweden is summarised by the tables for 1912, given below, in thousands of kronor—18 kronor equal £1.

Exports	Value in thousands of kronor	Imports	Value in thousands of kronor
Timber	285,365	Minerals, mainly coal	123,416
Metal goods and machinery ..	114,908	Metal goods and machinery ..	88,208
Live animals and animal foods ..	99,825	Raw textile material and yarn	75,781
Minerals	80,893	Wheat and flour	68,217
Metals	47,880	Colonial produce	60,340
Paper	40,352	Textile manfres.	53,996

The overwhelming importance of timber in these returns is obvious. Next come minerals and mineral products, animals and animal foods.

Of the total foreign trade of Sweden, 27 per cent. is carried on with Germany, the imports largely exceeding the exports, and 26 per cent. with the United Kingdom, in which case the exports exceed the imports. Next in order among the customers of Sweden are Denmark, Russia, France, and Norway. In 1912 the total value of the exports was 760,616,000 kronor, and the total value of the imports, 793,713,000 kronor.

Trade of Denmark. The trade of Denmark well illustrates the uniformity of the country, and the remarkable economic development of recent years. In 1912 the exports of the home produce were worth 596,723,000 kroner (18 kroner equal £1), and of this butter accounted for 191,088,000 kroner, meat for 176,144,000 kroner, and animals for 54,182,000 kroner.

The position of Copenhagen on the Sound, at the point of vantage between the North and Baltic Seas, makes Denmark a relatively important trading country. In 1912 its total value export trade was worth 682,082,000 kroner, of which home products formed about 87 per cent. Over 54 per cent. of this trade went to the United Kingdom, nearly 27 per cent. to Germany, and over 7 per cent. to Sweden and Norway.

The import trade of Denmark is largely in cereals (14·6 per cent.), metals and hardware (9·3 per cent.), coal, of which little is produced in the country (8·2 per cent.), textiles (7·3 per cent.), and colonial produce (5·8 per cent.). The total value of the import trade in 1912 was 817,512,000 kroner, of which over 740,000,000 kroner represented special imports. A remarkable feature of the trade returns is the import of provisions and eggs, which accounts for 6·9 per cent. of the total import trade.

These are collected from the other Baltic lands, to be shipped to Britain and other countries through Copenhagen.

Nearly two-fifths of the imports come from Germany (over 38 per cent.), and less than 17 per cent. from Britain. Sweden and Norway together supply 9 per cent., the United States 8·4 per cent., and Russia nearly 7 per cent. Its flourishing provision trade, the staple of its prosperity, is the result partly of the climatic conditions and partly of the excellent technical education given to its people. Its entrepôt trade is explained by its position.

Norway. Norway, the rugged land which occupies the western highlands of the Scandinavian peninsula, differs completely from Sweden and Denmark in configuration and climate. Its economic conditions are correspondingly different. Three-quarters of the surface of the country is unproductive; and of the remaining quarter, 21·5 per cent. is forested, leaving only 3·5 per cent. fit for cultivation. Under these conditions, maritime occupations (fishing, shipbuilding, the carrying trade, etc.) naturally rank among the principal industries of the country. Thirty per cent. of the population are engaged in agriculture, but to a very large extent these supplement their resources by fishing.

The figures for the export trade of Norway show how much the prosperity of the country depends on the fisheries and the forests. The figures for 1912 are given below. The krone has the same value as given above.

Exports	Kroner
Animal produce (malty food)	109,069
Timber and wooden goods	84,961
Hair and skins	27,313
Paper and paper manufactures	25,366
Minerals (raw)	17,458
Minerals (manufactured)	16,769
Tallow, oils, tar, etc.	15,709
Metals and metal manufactures	14,663

The import trade of Norway naturally consists largely of breadstuffs, since the country cannot raise its own, and groceries. Metals and machinery also form a considerable item. The figures for 1912 are:

Imports	Kroner
Vessels, carriages, and machinery	81,507
Breadstuffs	62,512
Minerals (unwrought)	58,527
Textile manufactures	43,520
Groceries	40,116
Tallow, oils, tar, etc.	39,925
Metals (manufactured)	37,237
Metals (unwrought and partly manufactured)	35,016

Among the customers of Norway, Germany now occupies the first place, being closely followed by our own country. Norway sends to Britain wood and wood-pulp, fish, stones, ice, and in return receives coal, cottons and woollens, machinery and ironwork. Fish is largely exported to Spain, Italy, and other Catholic countries. The mercantile marine has a total tonnage of nearly 1¾ million. Compare the German Empire (3 million tons).

Rumania. Rumania [see GEOGRAPHY, page 1872] resembles Southern Russia. Its great steppe-lands rise to the forested slopes of the Carpathians and Transylvanian Alps, so that agricultural and forest products form the staple of its natural resources; 60 per cent. of the population are engaged in agriculture.

The following table shows the nature of the trade in 1911, in thousands of pounds.

Exports	£1,000	Imports	£1,000
Grain	22,306	Metals and metal manufactures	4,902
Petroleum	1,585	Textiles	3,662
Beans and oil seed	1,408	Machinery	2,366
Wood	1,030	Wool, hair, and manufactures	2,045
Foodstuffs	265	Ready-made clothing	1,132
Animals	258	Hides	920

Cereals, forest produce, animal products, and oils from the petroleum wells are among the chief exports through the Danube ports, the most important of which are Galats and Ibraila. The exports go to Belgium, Austria-Hungary, the United Kingdom (wheat, barley, maize, petroleum, and timber), France, and Italy. The imports are obtained from the German Empire, Austria-Hungary, the United Kingdom (cottons, cotton yarn, iron, machinery, coal, and woollens), France, Italy, and Belgium. The total value of the exports in 1911 was 691,720,000 lei (25 lei = £1), and of the imports, 569,745,000 lei.

Bulgaria. Bulgaria somewhat resembles Rumania in the north, but it is narrower and less fertile. The chief agricultural area is in the Maritsa and Tunja valleys [see page 1874]. Cereals are exported to the United Kingdom, Belgium, Turkey, the German Empire, Austria, and France, and account for three-fifths of the total exports. The others are live-stock and their products, silk cocoons, and attar of roses. Textiles form one-third of the imports, and metals, machinery, and implements one-sixth. The imports come chiefly from Austria-Hungary (24 per cent.), Germany (20 per cent.), the United Kingdom (15 per cent.), and France (7 per cent.). The imports from Britain are cottons, cotton yarn, machinery, and metals. In 1912 the total value of the exports was £6,257,000, and of the imports, £8,524,000.

Serbia. Serbia is more rugged and forested than Bulgaria, and has a much smaller trade. Animals and animal products formed one-fourth of the exports in 1912, and cereals nearly one-third. Two-fifths of the export trade was with Austria-Hungary, and one-fifth with Germany. By controlling the trade routes from Serbia, Austria-Hungary was formerly able to exert an economic influence over Serbia, which is hardly less valuable than a political one. It has been said, indeed, that Austria's habitual method of curbing Serbian advances to other Powers is to proclaim the existence of swine disease in Serbia, and to prohibit the export of swine from that country into Austria-Hungary. The chief imports are cotton and woollen goods (20·5 per cent.), metals and machinery (20·8 per cent.), hides and leather (5·5 per cent.). Of these, 45 per cent. comes from Austria-Hungary, 30 per cent. from Germany, and only 8 per cent. from the United Kingdom. The total value of the exports in 1912 was 84,221,000 dinars, and of the imports, 106,094,000 dinars (1000 dinars = £40).

The Kingdom of Hungary. From an economic as well as from a political point of view, Austria-Hungary must be regarded as consisting of two groups of Powers. *Hungary* resembles Rumania in many respects, but has a greater mineral and industrial development, in addition to more extensive territories. The fertile plains or pastures of Hungary are no longer exclusively pastoral, but rich agricultural lands; 43 per cent. is arable, and 22 per cent. meadows and pasture land. The slopes of the Carpathians and other mountains are densely forested, so that 27 per cent. of the country is covered with trees. The agricultural and forest resources support 65 per cent. of the population. The rocks are rich in minerals, especially in the Bihar region, and in the North Hungarian Ore mountains, where gold, silver, copper, lead, antimony, mercury, and other minerals abound, but are not exploited as they might be. The mineral riches of Hungary will undoubtedly be a greater source of wealth in the near future.

The chief wealth of Hungary is agricultural. On the flat steppe-lands rich crops of wheat and maize are grown. The wheat is of extremely fine quality. Much of it is ground by the most modern processes, the different qualities being sorted out beforehand. Hungarian flour is the best on the market, and is better than flour ground in our own country by the same processes from Hungarian wheat. This is probably due to different climatic conditions, and to the effect of the voyage on the wheat. Budapest, Temesvar, and Poszony (Pressburg) are the chief milling centres, and Fiume the chief outport, but some of the wheat is sent down the Danube. Oats, barley, and rye are also grown.

Among other agricultural products are potatoes, beetroot, pulses, tobacco, hops; and even a little rice is grown in the Banat. Horses, cattle, pigs, and sheep are numerous. Hungary is noted for its vineyards, and its silk culture supports over 66,000 families.

Hungarian Manufactures. Manufactures are rapidly developing in Hungary. As in Canada and other lands where agriculture is expanding, much of the industry is connected with the elaboration of food, agricultural implements, and transportation plant. Thus, Budapest and Poszony (Pressburg) mill flour, and also make jute sacks for holding it, and the necessary machinery and rolling stock. Breweries and sugar-mills are numerous and important. Agram, in Croatia, is noted for its tobacco factories. The following figures, from the census of 1900, show the relative importance of the different manufactures, which occupy 12·8 per cent. of the working population—in clothing, 25 per cent.; in foodstuffs, 14 per cent.; in iron and other metals, 11 per cent.; in building, 11 per cent.; in wood and bone, 8½ per cent.

In 1912 the following was the value of the exports and imports in thousands of crowns (£40), each crown or kroner being equal to 9¾d.

Exports	Thousands of crowns	Imports	Thousands of crowns
Cereals	311,643	Cottons	197,537
Flour (wheat)	272,853	Machinery	130,812
Cattle (horned)	177,603	Woollens and semi-woollens	125,591
Swine	90,177	Ironware	91,350
Wine	67,855	Leather (prepared)	75,796
Timber	66,371	Coal	65,051
Sugar (raw)	65,050	Clothes	56,432
Sugar (refined)	44,505	Leather goods	53,886

Of the imports, 23 per cent. consist of raw materials, 14 per cent. of semi-manufactured articles, and 63 per cent. of manufactured goods. On the other hand, raw materials furnish over 50 per cent. of the exports, manufactured articles 40 per cent., and semi-manufactured articles 10 per cent. The prosperity of Hungary is essentially agricultural.

The Austrian Empire. The Austrian Empire [see page 1869] is more diverse economically than the kingdom of Hungary. It has to be divided into (1) Galician Bukovina, Bohemia, Silesia, and Moravia; (2) Austria proper; (3) Alpine provinces, Bosnia and Herzegovina; (4) coastal provinces.

Half the population depends on agriculture and forestry, and about one-quarter on various industries, manufacturing, metallurgic, etc., while nearly 8 per cent. are supported by trade and transport, and over 2 per cent. by mining; 38 per cent. of the land is arable, 35 per cent. is woodland, and 25 per cent. is pasture and meadow land.

Wheat, barley, rye, and oats are all extensively cultivated. Potatoes are a most important crop; maize, pulses, beet (in Bohemia), and vines are next in importance. Considerable areas, especially in Bohemia, are covered with flax, hemp, and hops. Live-stock is abundant. In valleys opening to the Adriatic silkworms are reared.

The mineral wealth is mainly coal in Silesia; coal, lead, zinc, silver, alum, and graphite in Bohemia; iron, zinc, and lead in Alpine states; iron, petroleum, and salt are found in the Carpathian foreland; copper is obtained in Salzburg, and mercury at Idria.

Austrian Manufactures and Trade. Manufactures are growing rapidly in importance, especially near the coalfields of Bohemia, Moravia, and Silesia, where iron manufactures are flourishing. Bohemia makes sugar from beetroot, much beer, especially at Pilsen, and brandy; cottons and woollens are manufactured at and around Reichenberg in the north, and linen and leather goods. Bohemia is also famous for its glass and porcelain. Vienna, like Prague and most other capitals, makes many articles of luxury, more particularly furniture, silk and dresses, and boats for the Danube. Paper is made in the forested Alpine provinces and Northern Bohemia.

TWO GREAT SEAPORTS OF THE CONTINENT

MARSEILLES—THE GATEWAY OF FRANCE INTO THE MEDITERRANEAN

A QUAY AT ROTTERDAM, THE RISING OCEAN PORT OF HOLLAND
(The lower photograph is by Mr. H. W. Nicholls)

The trade of Austria with the East consists of the exchange of manufactured goods for food and raw materials, but with the West it is rather an exchange of raw and half-manufactured goods for finished wares. The down-Danube trade is with Hungary and the Balkans, the up-Danube trade with South Germany. From Bohemia, trade passes by the Elbe valley to a North Sea outlet. Austria has its port in Trieste, on the Adriatic, with connections especially with Mediterranean and eastern ports.

Austria-Hungarian Trade. The trade of Austria-Hungary is five-sixths by land and one-sixth by sea. Naturally, most is with the adjoining lands of the German Empire, Italy, Russia, the Balkan States, Switzerland, and the not-far-distant France. British trade is largely through the Adriatic ports, and ranks second.

The exports and imports of the Common Customs Territory, which includes Austria-Hungary, the occupied territories of Bosnia, Herzegovina, and also the Principality of Lichtenstein, are :

Exports—1913	Thousands of crowns	Imports—1913	Thousands of crowns
Sugar	292,880	Cotton (raw)	336,075
Timber	247,493	Coal, coke, etc.	262,827
Eggs	137,372	Wool	141,478
Glass and glassware	88,264	Hides and skins	115,571
Lignite	76,524	Silk and manufactures	114,408
Woollens	64,809	Coffee	93,390
Leather gloves and shoes	60,623	Flax, hemp, and jute	85,910
Malt	55,697	Maize	83,806
		Machinery	80,837

Economic Decay and Advance in the Mediterranean Countries. The Mediterranean climate and products have received special attention in previous chapters. [See pages 1872 and 2004]. The peculiarity of rain falling in the winter half of the year is of great economic significance.

The economic development of the Mediterranean countries, however, depends partly on the configuration and position of the country, but even more on the stage of advancement of the population. In this long-settled area can be traced the rise and fall of peoples better than elsewhere, and the effects, economic and social, of different economic régimes.

Asia Minor, once the most prosperous part of the Mediterranean basin, is now the least so. The decay has been largely due to the neglect of roads and irrigation, the two ways which formerly permitted the circulation both of commodities and of the fertilising streams to the fields. The substitution of a pastoral for an agricultural civilisation leads inevitably to a decrease in the food-producing possibilities of the land, as well as to the diminution of its trading capacity, and the decay alike of its commercial routes and of the Government which protects a settled population.

Egypt, on the other hand, has progressed enormously in recent years through the security afforded by the reform of its government and the improvement of its irrigation.

Turkish and Egyptian Trade Compared. For the last three years for which figures are at present available, the average imports into Turkey amounted to £T34,000,000 (£T10 = £9 sterling), while the exports were valued at nearly £T20,000,000.

The following table shows the principal imports and exports in 1910-11 :

Imports	£T1000	Exports	£T1000
Textiles	13,864	Textiles	5,434
Cereals	4,810	Fruit	4,340
Sugar	3,229	Tobacco	2,705
Metals and manufactures	2,664	Cereals	1,991
Oils and fats	1,639	Drugs	1,397
Hides and skins	1,404	Animal products	1,018
Coffee, tea, spices	1,115		
Total	37,774	Total	22,474

The largest trade is with Great Britain, which sends 20 per cent. of the imports and takes 25 per cent. of the exports. Next in order come Austria-Hungary, France, and Germany.

With these trade figures compare the returns for Egypt for 1913 (£E1 = £1 0s. 6½d.). Perhaps the most telling proof of the advance of Egypt in recent years is to be found in a comparison of the trade for 1913 with that of ten years earlier :

Imports	1903 £E1 000	1913
Textiles	4,957	6,969
Cereals and vegetables	1,698	4,242
Wood and coal	2,222	3,838
Metals and manufactures	2,243	3,145
Spirits, oils	884	1,411
Chemical products	456	1,342
Provisions and drugs	441	1,066
Animals and animal products	781	1,051
Total	16,753	27,865

Exports	1903 £E1000	1913
Raw cotton	15,676	25,513
Cereals and vegetables	2,364	4,297
Tobacco	423	394
Animals and animal products	137	297
Skins and leather goods	82	237
Total	19,541	31,662

Nearly one-third of the imports come from Britain, in return for about two-fifths of the exports. Germany, France, and Austria-Hungary rank next in importance in the foreign trade of Egypt.

Greece. With its mountains and narrow plains, Greece is not suited to great agricultural development, yet the bulk of the people are directly dependent upon the products of agriculture. Currants and iron ore are the chief exports, with wines and oil secondary ones. One-third of the imports are agricultural products, and one-seventh raw minerals. By far the largest trade is with Great Britain.

The Western Mediterranean Lands. The western lands are much more advanced, and present a considerable economic contrast to those of the eastern basin. The lowlands are greater in area, and are more carefully cultivated. Wine and oil form an even more important part of their products. There is little industrial development, except in Northern Italy, Southern France, and round Barcelona, in Spain. Portuguese, Algerian, and Tunisian statistics are more comparable with those of the Eastern lands. Algerian, Moroccan, and Tunisian trade is still largely agricultural. Over 31 per cent. of the exports from Tunis, which are valued at 155,000,000 francs, consist of phosphates, 15 per cent. of mineral ores (iron, lead,

and zinc), and 13·5 per cent. of olive oil. In good years cereals form a considerable proportion of the exports. Textiles, grain and flour, iron, hardware and machinery, sugar, and coal are the principal imports. The bulk of the trade is with France. Next come Italy, Britain, and Algeria.

Algerian and Moroccan Trade. Algerian trade is much larger. The exports are worth over 508,000,000 francs. They resemble those of Tunis in many respects, but wine is the chief export, forming 30 per cent. of the total; cereals account for nearly 12 per cent., sheep for over 6 per cent., and hides, skins, and wool for 4·5 per cent. The imports resemble those of Tunis.

Over 80 per cent. of the total trade is with France, Britain coming next with little over 3 per cent. Germany and Italy both figure more prominently in the export than in the import columns, while Brazil, Spain, and the United States are more prominent in the import columns.

Moroccan trade is comparatively small. Products, such as eggs, almonds, wool, wax, birdseed, and beans, which require no great care to produce, are exchanged for cotton, sugar, and tea. The exports of grain (barley and wheat) are increasing. Two-fifths of the trade is with France and Algeria, and nearly 29 per cent. with Britain and the British possessions in the Mediterranean.

Portuguese Trade. Nearly half the country of Portugal is waste land, and 26 per cent. is under cultivation. Vineyards occupy 35 per cent., fruit-trees 3·9 per cent., and forest 17·3 per cent. of the total area.

Wine (over one-half of it port) is by far the most important export (nearly one-third), and cork comes next (one-eighth). Fish (especially tinned sardines), fruits, cotton, timber, and copper ore are other important exports; 24 per cent. go to Britain, 20 per cent. to Spain; 22 per cent. to Brazil, and 16 per cent. to the Portuguese colonies. Britain obtains 22½ per cent. of its wine from Portugal. Cotton and cotton goods, iron and steel manufactures, coal, wheat, codfish, sugar, hides and skins, and machinery are among the chief imports; 30 per cent. come from Britain, 18·6 per cent. from Germany, 9 per cent. from the United States, and 8 per cent. from France, Belgium, and from Spain.

The position of Lisbon makes it an important entrepôt centre, to and from which is carried produce from South America, more particularly from Brazil and from the Portuguese colonies.

Economic Divisions of Spain. There are four great areas in Spain: (1) The forested and mineral mountains of the north; (2) the pasture-lands of the Meseta and the Ebro valley, which are only here and there cultivated; (3) the mineral zone of the Sierra Morena and Sierra Nevada in the south; and (4) the fertile plains of Andalusia and the terraced hillsides of the coastal regions of the Mediterranean. In this region is Barcelona, the chief manufacturing centre, noted for its cottons, silks, woollens, and paper (made largely from esparto grass).

Spain has two outlets: (1) by the Mediterranean to the east and south and west; and (2) by the Atlantic to the west and north. The internal routes are poor and inadequate, and this greatly hampers Spanish economic development. One-third of Spain is cultivated, one-fifth produces fruits, and another fifth is under grass, while nearly 4 per cent. consists of vineyards.

Spanish Exports and Imports. From the north of Spain iron and iron ore and partially manufactured iron are exported, especially from Bilbao, where there are many ironworks. Some zinc and cobalt are also exported from this district. The southern mineral zone yields much copper (exported from Huelva), silver, silver-lead, lead, and mercury (Almaden). Metals and mineral ores amount to 24 per cent. of the total value of exports—1,146,000,000 pesetas (say, 33⅓ pesetas = £1).

The wine, grapes, and raisins shipped from the Mediterranean ports and Cadiz amount to nearly 25 per cent. of the exports.

Spanish imports include alimentary products, such as grains to a percentage of 16 per cent. of the total of 1,140,000,000 pesetas in 1904, while raw cotton formed 11·5 per cent. Iron, steel, and machinery formed 12 per cent. of the imports, and coal over 6 per cent.

Spanish trade relations are worth analysing. The eight States with the greatest trade are:

Country	Exports to	Imports from
	1000 of pesetas	1000 of pesetas
United Kingdom ..	236,229	200,597
France	257,681	182,954
United States	67,328	155,232
Germany	74,340	138,330
Portugal	50,279	56,858
Argentina	71,643	39,576
Belgium	49,913	33,122
Cuba	63,643	3,452
Italy	48,752	12,680

The preponderance of exports in the case of Britain, France, and Cuba is to be noted. To Britain and France are sent much iron ore, wine, and fruits; to Cuba, wines and manufactured articles. Britain, France, the United States, and the German Empire supply most of Spanish imports, mainly manufactured articles, with cereals, and cotton, in addition, from United States.

Economic Divisions of Italy. Italy is mainly agricultural, and over 70 per cent. of its surface is productive. Wheat is grown on 23 per cent. of the area under crops, and vines on 20 per cent., the olive groves and maize fields being next in importance. On the hill slopes mulberry and other trees flourish. On the Alpine meadows and grassy flood-plains many cattle are kept, and cheesemaking is important.

Apulia, which produces hard wheat from which macaroni is made, in the east, is divided by the Apennines from the fertile flood-plains and hill slopes of the west, while the Sicilian region and the Neapolitan Campagna, with their lemon, orange, and olive groves and vineyards, and Tuscany, with fewer oranges and more vines and olives, are the most productive. Except sulphur from Etna, marble from Carrara, iron ore from Elba, and some iron, silver, lead, and zinc from Sardinia, the produce is mainly fruits and wine and olive oil, with straw plait, and artistic articles for tourists.

Northern Italy is shut in by mountains. The irrigated northern plains are cold in winter, very warm in summer, so that not only wheat and maize but even rice is grown. The perennial streams yield abundant water supply for the electric power which is so important in an area where there is no coal. The chief manufacture is silk, the silk-worms being fed on the mulberry leaves, and the cocoons unwound in many villages. The chief

centres are Como, Brescia, Bergamo at the opening of Alpine valleys, and Milan, the great city of the plain. Engineering works have become of great importance at Milan, Turin, and other centres.

The outlets of this northern region to the sea are by Genoa, reached by fairly easy passes, and, to a less degree, through Venice. The Alpine tunnels connect it with the colder lands of Central and Western Europe, to which its richer produce is sent.

Italian Exports and Imports. Of Italian exports, raw silk is by far the most important, forming 13·5 per cent. of the total of nearly 2,500,000,000 lire (25 lire = £1). Cottons, dried fruits, silk manufactures, wines, cheese, hides, flax and hemp, eggs, olive oil, sulphur, and flour come next. Germany, Switzerland, Britain, the United States, and France are the chief customers for the exports of Italy; next come Austria-Hungary and the Argentine Republic, to which so many Italians have emigrated.

Over a series of years raw cotton takes first place in the list of imports, but in 1912 and 1913 its value was exceeded by those of wheat and coal, Italy being devoid of coal. Next in importance are the imports of timber, hides, boilers and machinery, scientific and electrical instruments, copper, woollen manufactures, coffee, and fish. In 1913 the value of the wheat imports was 406,000,000 lire, while the local raw silk was supplemented by the import of over 90,000,000 lire worth, mainly from the Far East. The total imports in 1913 amounted to 3,637,000,000 lire.

Germany supplies 17 per cent. of the imports, Britain nearly 16 per cent., and the United States about 14 per cent., in all cases the imports to Italy being far in excess of the goods sent in return. The next most important sources of imports are Austria-Hungary, France, and Russia.

The position of Italy is a favourable one for commerce. In touch through the Alpine tunnels with the Great Powers of Continental Europe, it is connected with the Atlantic and Indian Oceans by the Strait of Gibraltar and the Suez Canal. Though it cannot be expected to attain the preponderant part which it played in mediæval commerce, its economic development and commercial expansion are both assured.

Economic Divisions of France. The three mountain areas of the Pyrenees, Central Plateau, and Alps are of small economic importance compared with the three lowland areas, southern, western, and northern, each of which touches a different sea. [See pages 1477-9, where a full description will be found.] Nearly 42 per cent. of working people are farmers or foresters, 29 per cent. are engaged in manufacturing industries, 14 per cent. in trade and transport.

The southern lowlands of Languedoc and Provence face the Mediterranean, and belong to the Mediterranean type of country. Wheat and maize and lucerne are grown in the fields, but olive groves and vineyards are more important, and on the hillsides the mulberry flourishes and silkworms are reared. Silk weaving is carried on chiefly at Lyon on the Rhone, near the St. Etienne coalfield, where St. Etienne is noted for silk ribbons, but spinning is common through all the southern region of France. Marseilles is famous for soap, candles, and other works depending on copra, palm oil, and other tropical produce brought by its fleet of merchant ships from warmer lands. More wine is produced here than in any other division of France, and much of it is shipped at Cette.

The Western Lowlands and the Central Highlands. The western lowlands of the Garonne basin produce much wine (clarets), especially round the Gironde estuary, where Bordeaux is the port and chief commercial centre. Maize is still an important cereal. Throughout this area, fruit-preserving, especially of plums, is important. At Bordeaux, colonial produce, especially sugar, is prepared for the market. The central highlands support large flocks of sheep and herds of cattle, but agriculture is important in the fertile plains of the Loire and the Allier. Vineyards are found all round the margins on terraced hillsides facing the south, especially on the limestone heights of the Côte d'Or, which link the Central Plateau to the Vosges. Here the wines of Burgundy are made. The chief centres are Dijon, Beaune, and Macon. Small coal and iron fields round the margin give rise to numerous small industrial centres. The metal works of Le Creuzot and St. Etienne are the most important, but minor smelting and machine-making centres are in the Nivernais, Alais, and Rouergue. Woollens are important in Languedoc, round Bédarieux, and porcelains round Limoges.

Northern and Eastern France. The northern lowlands are mainly in the Seine basin, and they may be considered to extend westwards down the Loire to the Bay of Biscay, northwards through the low hills of Picardy and Artois, and eastwards across the heights bordering the Meuse and the Moselle. This is the centre of wheat and beet growing. Apple orchards and cider become important in the north. Vineyards and wines, including sparkling wines, are found in the south, in the Champagne and Loire districts.

There are four great industrial areas in Northern and Eastern France: (1) The Parisian district, making *objets de luxe*, pottery, paper, etc.; (2) the lower Seine, where English coal, American cotton, and Argentine wool can be brought cheaply to Rouen (cotton) and Elbeuf (woollens); (3) the eastern industrial area supplied with coal from the Saar fields, making iron and steel and cotton; (4) the northern coalfield, with its cottons, linens, and woollens made at Lille, Tourcoing, Roubaix, Valenciennes, Reims, and other centres, numerous iron and steel works, and many sugar factories, most numerous in the western margin, where most sugar beet is grown. Dunkirk is the outlet for the region, which is intersected by a good canal system running to Paris.

French Trade. The table given below shows generally the chief divisions of French commerce and their values during four successive years (a franc = 9¾d).

	Imports (1,000,000 francs)				Exports (1,000,000 francs)			
	1910	1911	1912	1913	1910	1911	1912	1913
Food products	1,400	2,025	1,800	1,900	850	725	825	82 5
Raw products	4,350	4,525	4,825	4,925	1,950	1,825	1,925	1,875
Manufactured goods	1,400	1,525	1,600	1,675	3,425	3,500	3,450	3,600
Total	7,150	8,075	8,225	8,500	6,225	6,050	6,200	6,300

From such a table we notice the variations from year to year, which it is not possible to analyse in the brief space at our disposal here. This, however, warns us to use mean values as much as possible. Further, we notice how France exports almost as much food products as it imports, and in this respect it differs from other industrial countries

of Western Europe. A third point is that both imports and exports of manufactured goods are increasing—a sign of healthy development.

French exports in 1913 consisted of textiles, 15 per cent.: silk, 5·9 per cent.; woollens, 3·3 per cent.; and cottons, 5·8 per cent., formed the most important class of exports. The fine French workmanship and taste ensure a market for highly priced goods. Raw wool and yarn, 4·6 per cent., raw silk and yarn, 2·5 per cent., are both important. Wine, 3·1 per cent., is the chief alimentary product; skins and furs (5 per cent.), automobiles (3·4 per cent.), Paris goods (3 per cent.), and metal goods (2 per cent.) come next.

Britain takes 21·5 per cent. of these exports (largely silk and woollen goods, wine, sugar, butter, leather, carriages, clothes, and cotton goods), Belgium 16·4 per cent., Germany 12·7 per cent., Algeria 8·1 per cent., the United States and Switzerland each 6 per cent. The United Kingdom is thus by far the best customer of France.

French Imports. Raw wool, 8·2 per cent.; cereals, 7·2 per cent., and raw cotton, 6·3 per cent., are among the principal imports. The lack of coal is made up by importation of coal and coke, in decreasing quantities, but still amounting to 6·7 per cent. of the total imports. Machinery, 3·8 per cent.; wine, 3·2 per cent.; hides and furs, 2·7 per cent.; coffee, 2·6 per cent.; copper, 2·4 per cent.; rubber, 2·3 per cent., and timber, 2·2 per cent., are the next items.

Britain furnishes 13·3 per cent. of the imports to France, the principal items being coal, machinery, woollen and cotton goods and yarn, and iron and steel. Germany supplies 12·6 per cent. and the United States 10·2 per cent. of the imports. Next in order are Belgium, 6·7 per cent.; Russia, 5·4 per cent.; Argentina, 4·6 per cent., and Algeria nearly 4 per cent.

British trade is thus by far the most important for France, then that of Germany and the United States, showing that countries well developed economically have very large trade with each other.

The French transit trade is considerable. The general exports for 1912 were worth 8,823,000,000 francs, those of French produce, 6,212,000,000, a difference of 2,611,000,000, or nearly 30 per cent. of the export trade. The favourable position of France in the Mediterranean and Atlantic and its contiguity to the great European States explain this trade.

The Belgian Industrial Area. The Belgian industrial area is a continuation of that of Northern France. It is especially famous for linen made from local and imported flax (at Ghent, Tournai, and Courtrai), woollens (at Verviers) from the Ardennes, as well as imported wool, and round Liége for steel and engineering works near the rich ironfields of the Ardennes and the zinc of Vieille Montagne. Lace is made at several towns (Mechlin, Brussels), and is still a considerable home industry, while at Antwerp sugar is refined, and beer and spirits are made.

Belgian Exports and Imports. The trade of Belgium presents many contrasts with that of France. It has not the same variety of agricultural produce, and the country is not nearly as self-supporting. Its rich coalfields, on the other hand, yield more than enough for home use. Its transit trade is even greater than that of France is. On the average of the last five years it forms 41 per cent. of the export trade of 5,518,000,000 francs.

Antwerp is one of the great wheat ports of the world. The wheat is distributed by rail, and also by water. It is towed in barges up the Rhine, even as high up as Strassburg. Some may even be sent to Strassburg by such a roundabout way as by the Meuse, and the Rhine and Main Canal, at a higher cost, and taking much longer time. As it saves the Strassburg merchant the cost of warehousing, this route is taken by part of the wheat.

Of the special export trade of 3,576,000,000 francs in 1913, wool formed 9·7 per cent., iron and steel 7 per cent., flax and yarn 6·9 per cent., hides 3·1 per cent., rubber (from the Congo) 3 per cent., while railway and tramway cars, chemical products, and zinc each formed 2·6 per cent. of the outgoing trade. Germany takes over 25 per cent., France 19 per cent., the United Kingdom 15 per cent., the Netherlands 9·4 per cent., and the United States only 3 per cent. of the exports.

Belgian imports for home use are valued at 4,583,000,000 francs. Wool (9·1 per cent.) and wheat (8·7 per cent.) are the principal imports, being followed by cotton (4·6 per cent.), hides (4·2 per cent.), seeds, coal, rubber, and chemical products each between 3 and 4 per cent., building wood, maize, machinery, and flax, each between 2 and 3 per cent.

Most imports come from France, over 18 per cent.; Germany, 14·2 per cent, and Britain over 10 per cent.; next in order are the United States, with 8 per cent.; the Netherlands, with 7 per cent.; Argentina, with 6 per cent.; Russia and India each with over 5 per cent. of the total imports.

Switzerland, the German Customs Union, and the Netherlands. The Central European countries have not the advantage of France in position, although in the sheltered valleys of the south the vine comes to perfection. Although Alpine tunnels and the Rhone valley afford routes to the Mediterranean, still most of the commerce finds its way north to the Rhine, Weser, Elbe, and Oder ports.

The Swiss and South German farmers cultivate maize, wheat, flax, hops, chicory, and tobacco on the richer lower plains, and barley, oats, and rye on poorer soils and higher fields. The terraced lower sunny slopes of the hills are covered with vines and the rest with forest, up to the level of Alpine meadows, above which comes the snow line in Switzerland.

The North German and Dutch plains are not suited for maize, and even wheat is not much cultivated. Towards the east and south-east rye becomes the most important crop. Potatoes, from which spirit is distilled, are abundant in the middle Elbe and all of the Oder basins, and sugar beet is a most valuable crop in Silesia and the area between the middle Elbe and Weser.

The Swiss Industrial Area. An important industrial area lies in the northern plateau of Switzerland, between the Alps and the Jura. Though hampered by an absence of coal, Swiss energy and education have developed great industrial prosperity, which is expanding with the increased utilisation of the abundant water power converted into electricity. Engineering works are important in the great towns of the north, especially at Zürich and Winterthur (locomotives). Cottons are made at St. Gallen and Zurich, and silks at Zürich and Basel. The watch trade is commonest in the south-west round Chaux-des-Fonds, Le Locle, and Geneva.

Swiss Trade. Switzerland exported 1,357,000,000 francs' worth of goods in 1912, and over

1,375,000,000 francs in 1913. Its manufactures, silks (21 per cent.), cottons (20 per cent.), clocks and watches (13 per cent.), and its animal food substances, as cheese, condensed milk, etc. (9·3 per cent.), are sent not merely to adjacent countries but over the seas. While Germany takes 23·6 per cent., Britain takes over 17·7 per cent., France 10·5 per cent., and the United States 10·3 per cent. of the exports.

Swiss imports in 1912 amounted to 1,979,000,000 francs, and in 1913 to 1,925,000,000. Switzerland has to import cereals for its industrial population (12·7 per cent.), while silk and cotton goods, minerals, colonial produce, and woollen goods form the next important items.

Germany (34 per cent.), France (19·8 per cent.), Italy (10 per cent.), Austria-Hungary and Britain (6 per cent.), and the United States (4·3 per cent.) supply the bulk of these commodities.

The South German Industrial Areas. The industrial areas in South Germany are in small groups. The only coalfield is that of the Saar valley, where ironworks are important, as well as in the Grand Duchy of Luxemburg. The iron ores east of Nürnberg supply material for the other smelting works. Engineering is important in the capitals of the different states and in other large towns. Cotton manufacturing is the most important textile industry. Chemical works of great importance exist in the northern part of this area.

Silesia and Saxony. The Silesian industrial area is near rich fields of bituminous and of brown coal. Iron industries are common near the former, at Gleiwitz, Königshütte. Engineering works exist in the larger towns, such as Breslau and Liegnitz. The local flax and wool make linen and woollen manufactures important all along the base of the Sudetes. Cotton is spun and woven at Breslau, Glatz, and Görlitz. Sugar is extracted from sugar beet at Breslau and other centres.

The Saxon industrial area has important coal, iron, and other metalliferous deposits. Freiburg is the chief mining centre. Chemnitz, Dresden, Leipzig, and all the larger towns have engineering works. Local wool makes the fabrication of woollen goods very important. As Saxony is in closer touch than Silesia with the oceanic routes by the Elbe and Hamburg, cotton manufacturing is much more important in Saxony. The potteries of Meissen (Dresden ware) and the book trade of Leipzig are special industries of this region. The salt of Halle, Stassfurt, and other centres gives rise to chemical works.

North German Industries. The industries of the North German plain consist mainly of those which elaborate agricultural produce. The most important is the preparation of sugar from sugar beet, especially between the Elbe and Weser. Berlin has the furniture, clothing, and other manufactures of a great capital, and it possesses the great advantage of being reached both by water and by rail. Hamburg may be regarded as the North Sea port of Berlin, and Stettin its Baltic seaport.

Westphalia and the Rhineland. The Westphalian and Rhineland industrial area is the most important of all. Rich in coal and iron, it has the great Krupp works at Essen, the hardware of Remscheid, and ironworks at all the chief centres, Aachen, Cöln (Cologne), Düsseldorf, Dortmund. Woollens, silks, and cottons are important manufactures.

German Exports and Imports. The German Customs Union, or Zollverein, includes Luxemburg. In 1912 the special exports were valued at 9,098,000,000 marks (1 mark equals 1 shilling), and in 1913 at 9,912,000,000 marks. Base metals and their manufactures (19·2 per cent.), agricultural products and foodstuffs (17·4 per cent.), and textiles (15 per cent.) were the most important exports in 1913. Next followed machinery and electrotechnical goods (11·5 per cent.), chemicals and drugs (9·6 per cent.), raw minerals (8·7 per cent.), and leather and leather goods (5·5 per cent.).

Britain takes 13 per cent. of the German exports, and Austria-Hungary takes 11·5 per cent.; the United States, France, and the Russian Empire each receive between 7 and 8 per cent., the Netherlands 6·7 per cent., Switzerland 5·7 per cent., Italy 4·4 per cent., and the Argentine Republic 2·6 per cent.

The German imports were valued at 11,016,000,000 marks in 1912, and 10,695,000,000 in 1913. Unlike France, Germany cannot feed its people on its own produce. Hence 66 per cent. of the imports consist of agricultural products and foodstuffs. Raw minerals form 10 per cent., textiles 7·5 per cent. and metals and manufactures 6·5 per cent. The food sent from the United States makes it the largest source of German imports, sending 14·4 per cent. of the total; from the Russian Empire 13·8 per cent. are obtained, while Britain and Austria-Hungary each supply about 7½ per cent., being followed by France (5 per cent.), India (4·8 per cent.), and Argentina (4 per cent.).

The Netherlands. Holland has little mineral wealth. It can import coal cheaply across the North Sea. It is essentially, however, an agricultural and commercial country, the industrial developments being mainly in the elaboration of produce from the rich Dutch colonies. Sugar and cacao are among the most important.

Dutch trade of home produce or for home use was valued in 1912 at 3,113,000,000 guilders exports, and 3,613,000,000 guilders imports (12 guilders equal £1). The following table shows the principal articles in the foreign trade in 1911 and 1912:

	Imports, 1000 gl.	
	1911	1912
Cereals and flour	573,630	518,771
Iron and steel	422,484	311,734
Textiles, raw and manufactured	126,788	199,866
Copper	194,277	169,860
Wood	107,288	126,347
Coal	113,560	125,838
Rice	100,457	99,576
	Exports, 1000 gl.	
	1911	1912
Cereals and flour	357,409	383,300
Iron and steel	296,040	238,849
Textiles, raw and manufactured	128,199	161,343
Copper	174,508	151,603
Paper	80,782	86,301
Sugar	76,166	85,523
Wood	67,571	65,314
Rice	64,879	60,229
Margarine	48,718	59,885

Of the Dutch exports, 48·5 per cent. go to Germany, 19·4 per cent. to Britain, 11·9 per cent. to Belgium, and between 4 and 5 per cent. to the Dutch East Indies and to the United States. Germany supplies over 28 per cent. of the imports to the Netherlands, the Dutch East Indies 13·7 per cent., the United States and Great Britain about 10 per cent., Belgium 9·5 per cent., and Russia over 8 per cent. In consequence of its position, Holland carries on an extensive transit trade, and it is not possible to analyse our trade with that country from our own trade returns, as much of it is really trade with Germany which passes through Holland.

A. J. AND F. D. HERBERTSON

The Kodak and the Film. Choosing a Subject. Focussing. The Stops. Exposure. Tank Development. Daylight and Gaslight Printing. Mounting.

FILM PHOTOGRAPHY

We all want to make pictures. The picture-making instinct is far older than the wish to communicate by means of writing, and has not the same logical and utilitarian aim. Only a small proportion of people have the time or the patience to cultivate this inborn need of making pictures, but the desire remains; and half the visitors to a gallery of paintings come away with the unspoken thought: "If only I, too, could put on paper or canvas some delineation of the world in which I move!"

And the nineteenth century saw the arrival of an invention which put picture-making within the power of all. Science has given us the camera, wherewith we draw not by means of a pencil but by means of rays of light; and while the invention of the railway, the telegraph, and the aeroplane may be more revolutionary in their results, it is hardly an exaggeration to claim that none of them make so direct and popular an appeal to a mere human instinct as does photography.

That mysterious instinct was, and is, a sound and wholesome one; and, now that countless people have been able to indulge it, they find that it has brought its own reward.

The Camera an Educator. It is actually the case that the camera trains its owner's observative faculties. Give a boy a camera, even the most toy-like, and at the end of six months' amusement with it his eyes will be amazingly sharpened. The camera is an educator unawares. It is an educator in spite of the circumstance that its user need know nothing about photography in the scientific sense. The pedant may mourn that photography has been made too easy, and that the watchword "Press the Button" saw the end of its educative value. It is a false presumption. "Press the Button" is no mere catch-phrase in excuse of laziness; it is the announcement that a gate of knowledge and happiness once permanently and inexorably closed to the majority of mankind is now open to all.

Those who had the time and the patience and the skill have never, since civilisation began, been prevented from entering that gate, and when photography first appeared there were plenty of enthusiasts willing to devote themselves to its toilsome practice. Today, if we wish, that devotion is unnecessary; we reap the fruits of previous workers in the shape of an extraordinary simplification of all apparatus and processes.

A firm belief in the value of this simplification governs the policy of the present chapter. It is purposely un-"scientific." A little guidance the photographer must have before he can make proper use of his camera; that guidance will here be set forth, in non-technical language. It concerns the photography of Everyman, not the photography of the specialist. The requirements of the latter are only briefly touched upon, inasmuch as whole libraries of learned volumes are already at his disposal, while the needs of him who is called the mere snapshotter—in other words, of nine hundred and ninety-nine camera-owners out of a thousand—are curiously neglected. At the Kodak, which is perhaps the best-known form of hand-camera, and the Kodak method, we may therefore glance first.

The Kodak. The Kodak consists primarily of a light-tight box, with a lens at one end and a sensitive film at the other. The scene at which the camera is aimed is projected, by the lens, on to the film, where certain chemical changes take place. When certain further chemical changes ("development") have taken place, the film displays, upon its surface, a picture of the scene.

Certain Kodaks are actually boxes; certain others present themsleves as boxes which, for the sake of foldability, have collapsible sides—the familiar bellows. As far as mere photograph-making is concerned, it is literally of no importance which type of Kodak the beginner selects. The cheapest will take photographs—and the dearest will take photographs neither better nor worse. Broadly speaking, the dearest have only this advantage—that in a poor light, or with a rapidly moving subject, they can on occasion take photographs when no photography at all is practicable with the cheaper camera. But if the cheaper is usable, the dearer is usable too, and generally with only equal, not superior, effectiveness.

One point should be mentioned here, and that is that many of the Kodak models are now autographic. This means that they take Autographic film—it costs no more than ordinary film—which enables the user to write any notes, such as the date or title of the subject, on the film at the time he takes the picture. This writing then appears on the margin between the pictures when the film is developed, and so becomes a permanent part of the photograph.

Perhaps the first thing to be said about the camera is that it works. Many beginners either blame their cameras for failure, or force camera mechanism which needs no forcing. It must be understood, then, that the various knobs, buttons, and screws with which the Kodak is fitted all have a reason, and all will behave properly if properly handled. No wrenching or forcing whatever is needed to actuate any part of any Kodak. A Kodak is a machine, and works with the smoothness of a machine. Everything "works," and works so beautifully that only gentleness is wanted. Violence will put it out of order. But gentle manipulation is not inconsistent with firmness of manipulation. Removing the back from the folding Kodak should be done by a firm but not twisting grip of the pair of catches. The back comes away as light as a feather, and quite silently. And the roll of film loads into the back of the camera with the same quiet facility. *Read the instructions carefully* is a golden rule; and every camera-vendor agrees that it is a rule sadly neglected.

Fogging the Film. It is not the purpose of these articles to save the beginner from reading makers' instructions, but rather to treat of matters which those instructions omit. We shall therefore take it for granted that the actual loading of a film-cartridge into the Kodak is plain to the student, and shall pass on to remind him that, if light is

going to impress a picture on that film through the lens, it may, if care is not taken, reach the film without first passing through the lens, and impress it in such a way as to make it useless.

Should the spool of film become unwound, light will edge in at the crevices, and what is called "fogging" will ensue. *Fogging* is the spoiling of the sensitive film by light from outside the camera.

When the roll's seal is broken, the roll being in position in its nook in the camera-back, a gentle but firm finger-tip must hold down the outer paper while it is wound off on to the receiver; and the moment the receiver has got a good grip of the end of the paper, the back of the camera should be gently but firmly put into position once more. Now the film is safe, inside the camera; but after the exposure, when it is being taken out of the camera or placed in the winding-box which precedes tank-development, it is again unsafe, and again gentle but firm fingers will keep the spool tightly wound, allowing not too much of its paper to unwind.

This carefulness in avoiding fogging becomes second nature after a very little use of the Kodak, as also the habit of loading and unloading not in full sunshine but in the shade.

The Choice of Subject. Suppose, then, that you have loaded the film into your Kodak, and are ready to take your first picture. What shall be its subject?

Snapshots must be made in daylight, and preferably in sunshine. This is a limitation hardly to be grumbled at when we recollect that, down to the minutest detail, the scene is caught by the film in a tiny fraction of a second. But if photography today consists largely in pressing the button of a Kodak, why are not all snapshots alike, equally irreproachable? And not only is there a wide gulf between the bad photograph and the good one. Even the good ones are strangely dissimilar.

This is because photography, though achieved with the aid of a machine, is not mechanical. Snapshots all differ, for the obvious reason that the button may be pressed at an infinite number of different moments while the Kodak is aimed at an infinite number of different subjects in an infinite number of different circumstances. All these factors are dependent on the personal taste of the user of the Kodak; not one of them on the Kodak itself. That is why a lesson in the art or hobby of photography need have no concern, strange though it may seem, with the choice of camera, lens, or film, while treating in some detail with the use of each and all of them.

The beginner must grasp that it is at the outset more profitable for him to recognise the limitations of photography than to waste film by snapping here and there in the hope of luck producing results. There is no luck in the matter. When a photograph turns out badly, or does not appear on the film at all, it is the photographer's fault, and generally it will be found he has attempted something unphotographable.

We must examine, therefore, the table of lights and subjects sent out with the film, and remember that, while snapshotting in dull weather is not impossible, bright weather should preferably be chosen for the first attempts, and these must not be made either before sunrise or at dusk, even when the sky, under these conditions, looks wonderfully bright to the eye. Let us therefore set out to make our first exposure on a sunny day, preferably in summer; and although a street-scene, a race, or other subject in rapid movement is quite within the scope of the camera, let us begin with a non-moving subject. We shall find it easier and we shall not be flurried. We shall have plenty of time to think of the various factors which govern the success of our first picture. Let us imagine ourselves going out into the garden to make a portrait of a friend or relative seated there—not "posed" and not "being photographed," but just enjoying the warmth and reading a novel.

Taking a Snapshot. To get his full figure only, we shall have to stand quite close up to him—a mere six or eight feet away—whereas to get him full-length, with some of the surrounding garden visible on each side of him, we may stand farther off—say, fifteen feet distant. It is upon this circumstance that the whole of the procedure known as *focussing* depends.

Focussing. The booklet of instructions supplied with the Kodak draws your attention to the existence of the focussing-scale, which is visible on the right-hand side of the baseboard of the instrument when opened. (We allude, for the moment, to the folding Kodaks which take pictures $4\frac{1}{4}$ in. by $3\frac{1}{4}$ in., postcard size, and $6\frac{1}{2}$ in. by $4\frac{1}{4}$ in.; the small-size non-focussing Kodaks will be dealt with later.) This scale is marked with figures which denote feet, and refer to the number of feet of distance at which the subject is from the camera: 6 ft., 8 ft., 10 ft., 15 ft., 25 ft., and 100 ft. The front of the Kodak, carrying the lens, can be pulled out and fixed opposite any of these feet-figures. But it must be opposite the correct feet-figure, otherwise you will not get what is called a sharp picture. If, for example, you snapshot your friend when he is seated 10 ft. away, and your focussing-scale is set at the 25 ft. mark, the portrait will be blurred; but perhaps, beyond the sitter's shoulder, you may catch a glimpse, in the picture, of a tree which happened to be 25 ft. away, and it is not blurred: on the contrary, its trunk and its every leaf is distinct, clear-cut, and sparkling.

And the portrait would have been just as disappointing if the sitter had been 25 ft. away and you had set the scale at 10 ft. Therefore, we must learn to judge distances at sight, otherwise we shall always be setting the scale wrongly, and making pictures in which the principal object is blurred and some other quite unimportant object, nearer or farther off than the principal one, is needlessly sharply rendered.

Judging Distance. Standing a little way from your friend, measure with your eye the distance from the base of his chair to your own boot-toes. It pays to train yourself from the start to estimate distances accurately. Having guessed the distance from yourself to your friend, check your guess by measurement. The simplest form of measurement (rough and ready, but accurate enough) is to stride the distance, allowing 3 ft. for each step. The really keen amateur, determined to cultivate a strictly accurate mental measuring-tape, will find that the preliminary employment of an actual measuring-tape is repaying.

Let us suppose that in this instance, as we want to take a full-length portrait and include in the picture some suggestion of the surrounding garden, we stand 15 ft. away from the sitter, and set the focussing-scale accordingly. You will observe that had you intended to take the sitter at 10 or 6 ft. distance, the front of the camera would have had to be pulled farther out from the back. The nearer the object to be photographed, the farther must the

lens be from the film; but in practice we shall seldom, if ever, require to take anything closer than 6 ft. On the other hand, if the principal object in our picture, whether a figure or otherwise, be 100 ft. distant or more, it is (in practically all cameras with which the average amateur would be likely to deal) at what is called the *infinity point* of the lens. When set at the 100 ft. mark on the scale, the lens need be racked no further inwards. Everything at or about 100 ft. distant in the picture, and everything beyond, will be sharp.

Fixed-focus Instruments. In some smaller Kodaks the front, containing the lens, is so arranged that it either will not move at all or becomes automatically fixed at a certain point. No focussing is required. Provided the nearest object in the picture is not nearer to the camera than a given distance (a distance which, in the smallest Kodaks, is quite a short one), everything in the picture will be sharp. Kodaks of this type are called *fixed-focus* instruments, and the beginner will find them easy to use, no mental measuring, as described above, being demanded. For purely optical and scientific reasons, which need not be enlarged upon here, it is impracticable to make a good fixed-focus camera to take pictures larger than "quarter-plate" (that is, 4¼ in. by 3¼ in.); and the fixed-focus lens, though much excellent work is done with it, has certain drawbacks, apart from the smallness of the picture it takes, which cause the more experienced amateur to prefer the focussing lens.

To return to the taking of our portrait. We have focussed on the sitter. Therefore we know that he will appear sharp on the film. What else have we to think of before we make our exposure? What other precautions against failure have we to remember? There are four:

Subject, Light, Stop, and Duration of Exposure.

The subject we have already chosen; also the light, which is bright sunshine—that is to say, the best light which occurs in Nature. Remains, first, the stop, or aperture; and, second, the duration of exposure.

The Stop and its Manipulation. The *stop*, or *aperture*, is the hole through which the light reaches the film. It is really a window, rather than a hole, and the glass of the window is the lens. But the size of the hole is described as such-and-such a stop, or aperture, and that size can be decreased or increased within certain limits, though the lens remains the same size. In this way, by enlarging or reducing the size of the stop, the photographer can regulate the amount of light that enters his camera through the lens.

In the box-form Kodaks two or three different-sized holes are arranged on a plate, which can be moved so that one hole or another comes opposite the lens window; in the larger folding Kodaks, with which we are mainly concerned, the hole is formed of a device called an *Iris diaphragm*.

Examine the front of your camera, and under the lens you will see a little pointer, which can be pushed around a semicircular dial. Marked on this dial are the figures F/8, 11, 16, 22, 32, and 45; and on others, especially Kodaks, a different and perhaps simpler system of numbering is adopted, and the exact meaning of these numbers is explained in the instructions given with each Kodak. Whatever system is adopted, these numbers indicate the size of different stops. Although with the shutter closed you cannot see any change in the lens when you move round that pointer, a change is actually taking place, and can be observed if the shutter is set at "Time" and opened. What is happening as you move the pointer of the Iris diaphragm round is this: a kind of metal mouth, which at F/6 or F/8 is wide agape, gradually closes, until at F/32 or F/45 it is a mere speck of an aperture. This mouth is the entrance through which the flash of light has to dart in order to impress the picture on the film when we press the button. And it is clear that far less light gets through the mouth when it is small than when it is wide open. So, remembering what we said about the necessity of light for photographing, we perceive that, if more light (as is obviously the case) gets through the lens when the stop is, say, F/8 than when it is F/45, a shorter exposure will be allowable for a picture taken with the former (or larger) stop than with the latter or smaller. And as short exposures are very desirable—for we want to snapshot, not to be bothered with a tripod and time exposures—we deduce that the F/8 or F/6 is the stop which we should use.

Why, then, is any other stop provided? If all our snapshots are to be taken at F/6 or F/8, what is the use of making the Iris diaphragm to close up to a smaller aperture at all? The beginner need not concern himself with any stop smaller than F/11, or perhaps even F/16. These demand time exposures, and belong to advanced photography. The worker to whom such small stops would be of use is beyond the requirements of the instruction here to be conveyed. But the larger stops—F/11, for instance—are on occasions useful even in snapshotting. When are they useful, and what is their function?

Securing a Sharp Picture. To begin with, let it be laid down that we should do without any stop smaller than the largest if we can; and, secondly, we may only use as small a stop as F/11 in a very bright light, and for an open subject. We might, for example, use F/11, or even perhaps F/16, on a brilliant day at the seaside; and although only a quarter as much light gets through the lens at F/16 as gets through at F/8, there would still be sufficient light to take a picture, because by the sea there is far more light than inland. Still, however, we have not explained why we should not permanently use F/8 or F/6, as the case may be. And to answer this it will be necessary to make a statement, and then leave it unexplained, because there is no space here to expound the reason for it. The statement is this: the smaller the stop, the sharper will the picture be.

But if we have focussed sharply on our principal object, how can it be made any sharper than sharpness? It is not. But the neighbouring objects can be made sharper. Our friend in the chair on the lawn will be sharp on the film if we take him at 15 ft. distance, and set the scale accordingly. But the grass a little nearer the camera, and the trees some way behind the sitter's chair, will be blurred. By closing the Iris diaphragm to F/11 or F/16 we sharpen up that nearer grass and those distant trees, and so get a picture which is sharp all over, not only sharp at that section of it which happens to be just about 15 ft. from the camera.

Duration of Exposure. Suppose we want this sharpness, though, we must pay for it by increasing the duration of exposure. And duration of exposure was last of the quartette of factors which we decided we had to weigh carefully before pressing the button. The beginner may reply that duration of exposure is no affair of his. He only wants one duration of exposure—namely, the

snapshot. But there are snapshots and snapshots; and if in the smaller and more primitive Kodaks to which we have referred—which reduce the art of photography to its simplest elements—exposures of only one duration, or perhaps at most two different durations, are allowable, in the somewhat larger Kodak here postulated quite a number of exposures of different duration may be made, as the fitment called the shutter will presently prove in response to our inspection.

ARCHITECTURE WITH A KODAK—THE TOWN HALL, OXFORD

The *shutter* is a mechanism for opening and closing the window of the lens.

The book of instructions, and a good look at the shutter, will show you that—quite ignoring all "time" exposures—it is possible to give, for instance, a fiftieth of a second or a hundredth of a second exposure. Both are snapshots, but one is obviously twice as long as the other; and though both are—to the unscientific mind—unthinkably short, they are both long enough to affect the sensitive film very appreciably.

The beginner naturally wants to know which exposure he shall give, and this is precisely one of those questions which cannot be answered offhand, for its answer depends on several circumstances—the subject, the amount of light, and the stop to be used. The whole four are inextricably interlinked in our calculations; it is impossible and useless to consider one without its partners. With a bright light, fully flooding the subject, and with a large stop, we can give a fast—for instance, a hundredth of a second—exposure; with a bright light and a smaller stop we must lengthen the exposure; with a bright light and a still smaller stop we must give an even longer exposure, and so on. Each depends on the others.

The types of subject, light, stop, and exposure, all in their due relationship, are admirably set forth upon leaflets and in handbooks which every amateur will obtain with his Kodak, and with every spool of film for use therein. Here—after mentioning the stops and possible exposures as above—we find subjects divided into "landscape," "marine," "street scene," "outdoor" group, and others; and light into "brilliant," "cloudy," and "dull." These we shall for the present ignore, concerning ourselves only with the actual experimental subject which is to furnish us with out first essay in photography.

Our garden portrait—what exposure shall we give it? Supposing that our stop is F/8, that we are 15 ft. distant from the sitter, and that the sun is shining on him from that part of the sky which is more or less behind the shoulder of the photographer, it is safe to say that a fiftieth of a second's exposure will give a good result. Should there be white clouds in the sky, so that the sunshine is a trifle diffused, we may allow for this, and give a twenty-fifth of a second. We set the shutter accordingly, doing so as in its instructions. And we are now ready to aim the camera.

Aiming the Camera. Merely straight aiming is, of course, managed by means of the little apparatus known as the *finder*—that miniature camera on the side or top of the real camera in whose glass we may see a tiny picture of the scene which we intend to photograph. Looking down into the finder, we take aim in such a way that our sitter in his chair is somewhere about the middle of the finder's miniature—when the image of him will fall at the middle of the film when the button is pressed. The finder, then, is really a sighting apparatus; it helps

us to aim straight and also to get the scene level, for it is important to hold the Kodak level, though a very little tilting upward or downward—in a portrait—is of no consequence. In aiming the camera, too, we must take pains to hold it quite steadily. It is held against the body with both hands, and the photographer must momentarily hold his breath when he is pressing the button.

Releasing the Shutter. We have spoken throughout of pressing the button, because this is the popular phrase; actually, the releasing of the shutter is done either with a squeeze-bulb, a patent flexible wire release, or a trigger. Different types of Kodak have different devices; their function is all the same—to set off the shutter. All that the photographer must remember is that, whatever release he uses, he must press it gently but firmly, not with a jerk or hard push.

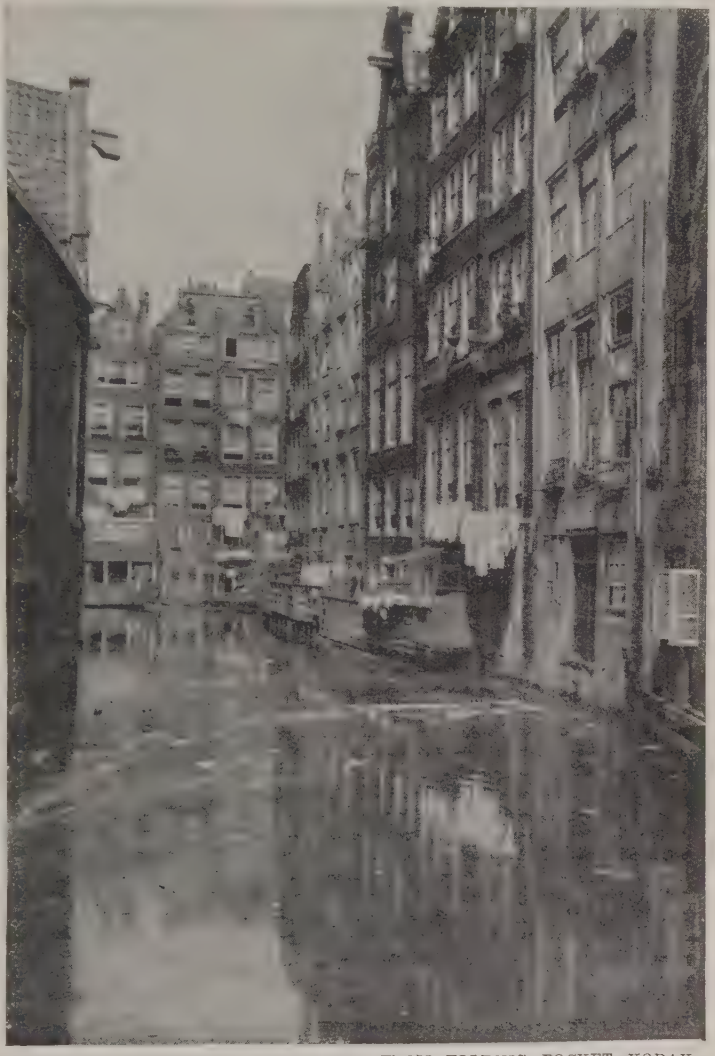
Ascertain that the film is in position by examining the little red window on which the number 1 of the film appears, see that the stop is the one chosen, set the shutter, aim the camera by observing the picture in the finder, hold camera and body rigidly and hold the breath, then set off the shutter release.

The portrait is taken.

Over-expose rather than Under-expose. We have now reached the first stage in the making of a picture by photography; we have snapped a portrait, or, in the more serious phrase, we have made an exposure.

The photograph is by this time either a good one or a bad one. Nothing can alter it now for the better, and nothing except a mistake in after-treatment, or deliberate mishandling, can alter it for the worse. All photographs must be rightly exposed in the first instance. It is true that a slight deviation from the theoretically "correct" exposure may make no very visible difference in the long run. To the ordinary amateur it is of no practical consequence, for example, if the "correct" exposure happens to be a thirtieth of a second, and he actually gives either a twenty-fifth or a fiftieth. Given that the weather is bright, and the subject an average one, there will be little difference to be detected, when development is over, between a strip of film which has received a twenty-fifth of a second and a fiftieth. When in doubt as to which of two exposures to give, the cautious amateur will choose the longer, unless his subject be lacking in contrasts of light and shade.

What is called the "latitude" of the film compensates, to a wonderful extent, for slight over or under exposure. Latitude is a characteristic the practical effect of which, as far as we are concerned, is that the various different exposures on a strip of film are all rendered much more nearly correct than if the film, having no latitude, required a certain precise exposure to give you a satisfactory result. Your first picture, for instance, may have a good deal of shadows, the second be in a blaze of sun, the third be a portrait, the fourth a seascape, and so on, and probably each is minutely "incorrect" in its exposure; yet, thanks to the "latitude" of Kodak film, all will turn out equally pleasing. It will be seen that this levelling up, due to latitude, is an essential quality in any film which is to produce tolerable photographs at all, for every photograph, without exception, is a compromise in the matter of exposure. Every photograph, that is to say, contains parts which are well lit and parts which are less well lit.



VIEW IN AMSTERDAM—ENLARGED FROM FOLDING POCKET KODAK

When we have developed our portrait we shall see that the details in the scene at which the camera aimed are all visible to the eye. Yet some of those details must, in the nature of things, have been under-exposed and some of them must have been over-exposed. Our sitter was perhaps garbed in a dark suit, wore a white collar, and cast a shadow on the ground. A moment's thought will show that, if minutely accurate exposure were demanded, we should not be able to take all those things simultaneously. More light is reflected from the white collar than from the suit, and more, perhaps, from the suit than from that part of the grass below the sitter's chair which is in shadow. And, bright though the light reflected from the white collar may look to the eye, it is nothing compared with the brightness of the patch of sky which we have included in our picture above the sitter's head. It is probably no exaggeration to say that a thousandth of a second would not have been too short an exposure for the sky; and if a two hundred and fiftieth of a second was correct for the linen collar, we may guess that ten times as long would be necessary for the suit, and longer still for the shadow.

We have chosen a medium, striking a kind of average for the whole; and a twenty-fifth or fiftieth of a second has, as an inspection of the developed film shows us, actually managed to capture all, or virtually all, the details, in every grade from absolute white to deepest shade. This capacity, as has been said, is due to the latitude of the film. Nevertheless, there is one fault for which even this, the best sensitive material, cannot compensate, and that is severe under-exposure.

Under-exposure a Grave Error. Under-exposure means that insufficient light has reached the film to impress a picture on it. Only a miracle can develop a picture, or a part of a picture, which has never reached the film. Hence the recommendation to err on the side of over rather than on the side of under exposure.

In snapshotting—by which is meant instantaneous photography, as contrasted with time-exposure photography—over-exposure is a very rare fault; a fault, therefore, which may generally be risked with impunity if there is any doubt in the mind of the snapshotter. An old maxim of photography says: "Expose for the shadows, and let the high-lights take care of themselves." This proverb was coined in an era when plates had but little latitude and films were unknown, but it still contains a germ of valuable sense. Unless his picture is one possessing no shadow parts at all (and such scenes are very rare in Nature, except at the open sea), his bright parts will—thanks to latitude—be none the worse of the over-exposure which they have suffered, and its dark parts will be all the better, if, indeed, they have been over-exposed at all.

The object of this short digression on the subject of over and under exposure, and the boon of latitude which modern film-makers now offer us, is to give weight to the suggestion that we might now, with profit, expose the remainder of our strip of film on the same portrait, but giving different exposures. For before proceeding to the task of development we may as well use up the whole of our film-cartridge instructively.

Supposing the spool of film is sufficient for six pictures, the five remaining ones should be snapped on the same portrait over again, giving it two or three of the different exposures which the shutter allows of, and taking it from different distances. This procedure will make the photographer familiar both with his shutter and with the use of the focussing-scale. Naturally, if anything is to be learnt from these variations, a careful record must be kept of the distance, stop, light, and exposure for each picture.

Winding off the Film. Without closing the camera, if it be of the folding type, turn it over, lens downward, and at its back you will notice a little round red patch, resembling a seal, the size of a threepenny-bit. This is transparent, and is really a tiny red window, through which you can see the back of the long strip of paper in which the sensitive film is wound. At present the number "1" is visible through the window; by slowly and carefully turning the winder the number "1" is caused to disappear, and presently "2" takes its place. A fresh strip of sensitive material is now in position, and we may proceed to make our second exposure.

There are trifling differences in procedure involved in the use of the various patterns of Kodak, but the used film should be wound off immediately after each exposure, or it may be forgotten, and two pictures will be taken on the same piece of film, the consequence being that both are spoilt.

Removing the Spool. When the last exposure of the strip has been made, the film and its protective paper are wound off. The spool of paper, with the film safely wrapped up in it, can now be taken out of the camera. The V-shaped loose end of the paper is stuck down, a portion of it having first been folded in, to make a little ridge. By leaving a tiny ridge of folded-in paper, we make the detaching easier when the spool has to be unfastened: the stuck strip can be torn, not cut.

In removing the spool from the camera, prior to sticking its end down, be careful to hold it gently but firmly, preventing any tendency to unroll. If the spool should unroll a little or become loosened, light may get in at its edges, and our pictures will be spoilt. Not until development is over can the film safely be exposed to even the faintest light.

Development. Within the paper-covered spool which we hold in our hand now there is a strip of pictures. In order to make those pictures visible a further chemical change must take place, and this is called development. This second chemical change is brought about by the application, *in total darkness*, of a certain liquid, called the *developer*, to the exposed film. After the photographer has used the developer and applied an intermediate dose of clean water to his film, he will have to immerse it in a second liquid, called the *fixer*. These two substances, the developer and the fixer, he will buy ready-made. They are sold in powder form, and are dissolved in water when needed. The method of dissolving and the quantity of water are both clearly specified on the packages.

Before the invention shortly to be mentioned, it was necessary for every amateur either to do the developing of his photographs at night, or else to set aside in his house a special apartment for the purpose—a so-called *dark-room*. But as the dark-room is now no longer necessary for unwrapping and re-wrapping sensitive material, so it is no longer necessary for developing films. It has been abolished by the invention of the *developing-tank*.

The Developing Tank. The developing tank will have been bought at the same time as the Kodak, and five minutes' study of the tank and of the pictures in the pamphlet which accompanies it will show its principle to the purchaser. The function of the tank, and of the box which goes with it, is to provide a substitute for the dark-

room; to provide, in fact, a miniature dark-room into which the strip of exposed film can be introduced, and there treated with the developer.

Ingenious mechanism was invented to enable the film to be wound off inside the camera and then wound up again for taking out. Similar mechanism is used in connection with the developing-tank. Within a light-tight wooden box the spool of film is wound into a wider tape of quite opaque celluloid (the "apron"), and this packet forms what might be described as a flexible dark-room in itself.

Encased snugly and safely within the encircling walls of this tubular dark-room, our exposures can be lifted out of the winding-box and dropped into another box, a tin one called the "cup," which is already partly filled with developer. The developer rises up around the packet, penetrates into its spiral folds, reaches the film there, and duly develops the pictures—without the photographer having had to touch the film and without any risk of light-rays reaching it.

Now, it is plain that as soon as the rising liquid of developer reaches the film it begins to do its work of development. But how are we to know when it has ended its work, or has done enough developing?

The photographer who has exposed a plate takes it into his dark-room, which is not really dark, but has a lamp which gives a feeble red light. Beneath the gleam of this light he pours developer on to his exposed plate, and, watching it, he can see when the picture has appeared sufficiently and it is time to pour the developer off. But our exposed film is hidden inside its apron, and even the apron itself is hidden inside the developing cup. So we cannot watch it to see when the pictures are finished. If we opened up the apron to have a look at the film we should spoil all our pictures by letting in light, and so causing fogging. The inference is that we must guess the length of time during which the developer must be left to attack the film. In actual practice, however, no guessing is required. We shall know, to the minute, just how long to leave our pictures in the developer.

A COTTAGE IN HUNTINGDONSHIRE—TAKEN WITH A KODAK JUNIOR

The Period of Development. For as in exposure we saw that there was a kind of averaging which made fractional errors negligible, so in development we strike a similar average. It is true that the piece of film which has "seen" most light will develop more quickly than another piece of film which has seen less light. But correct development will strike a balance between them, so that both are as good as human agency could conceivably make them. And correct development, as it happens, is an ideal far easier arrived at than correct exposure. With the tank or "cup," which contains a known amount of liquid, with the developing powders, which contain known quantities of certain chemicals, and with the film, which is of a known sensitiveness, it is possible to announce with absolute precision that any set of exposures of whatever sort must remain in the developing-cup, immersed in the developer, for a given number of minutes; and when the pictures are taken out they will be the best possible to produce by whatever method of development could have been tried.

Be it noted that this mechanical but rigidly scientific system of dark-room-less development depends absolutely for its success on the factors mentioned—namely, the developer, the capacity of the cup, the invariability of the film, and also the temperature of the developing solution—which will be dealt with presently. It is because the two first factors are vital ones that we assumed the necessity of using ready-made developer and a ready-made tank. The scientific chemical staff who make up these developers have adjusted them to an irreproachable perfection of accuracy, and no amateur compounding his own developer could possibly achieve this perfection; further, should he alter the developer, he will certainly alter it for the worse. It is literally the case that the photographer who nowadays makes up his own developer is doing just as uneconomic and—far worse—just as unpractical a thing as if he tried to build his own camera, grind his

own lens, or coat his own sensitive emulsion on strips of celluloid for film.

Temperature of the Developer. The exposed film, then, is to be left in the developer for a perfectly definite given time, and then taken out, with the certainty that the best possible pictures have been developed in spite of the fact that we have not yet had a glimpse of them. What, then, is that definite given time? Here we reach the one variable factor in our calculation. That factor is the temperature of the developer. If the developing liquid is cold it will develop more slowly than if it is warm. Totally cold developer will not develop at all, and very warm developer will spoil the film. We want our developer, then, to be of a certain normal temperature; and the "normal" is 65° F. A little above or a little below will do equally well; but, whether above or below, we must know just what the temperature actually is, and to ascertain this we must use a thermometer. Any thermometer, dipped into the liquid in the developing-cup before the apron-enclosed film is put in, will do, but suitable thermometers are provided by the tank-makers.

With the tank we find a book of instructions which tells us how long, at each temperature, the film should be left to develop. At the normal (65° F) it should be left for *twenty minutes*. At a lower temperature it should be left longer; at a higher temperature it should be left less long. Precisely how long, the temperature-chart will tell us. Do not guess the temperature of your developer. Sometimes you may guess right, but a day will come when you guess wrong, and spoil a strip of exposures. Guessing is not only disrespectful to your materials; it is inexorably punished by the waste of those materials.

The theory of this method of film development has taken some paragraphs to explain, but the fact remains that it is perhaps the simplest of all photographic processes, and certainly one of the most fascinating. Those who have watched friends engaged in the old and messy systems of developing plates will be astonished at the cleanliness, rapidity, and ease which have ensued from the introduction of the Kodak film tank.

When you buy the tank you will find enclosed with it a booklet giving full instructions. Usually, indeed, you need not read it, as most Kodak dealers are keenly interested in their business, and they will develop a spool before you, and so give you all the instruction you will require.

After development, the film has to be fixed. It is best to buy the developing powders made on purpose for the tank, and it is also true with regard to the acid fixing salt which is made for fixing Kodak film.

Your pictures are now before you, but they are in the form of *negatives*. Your friend's portrait shows him with a collar that is nearly black and with boots that are nearly clear film. But before you can get *positives* or ordinary photographs from them, the film must first be *thoroughly* washed to free it from the fixer, and dried. Full directions are given in the instruction books given with both the Kodak and the tank, so space need not be devoted to it here. Printing is the next operation to be dealt with.

Printing by Daylight. We are now at the stage of having got a negative. It is our purpose to turn that negative into a negative of the negative—that is, a positive. We are going, in short, to make a *print*.

The paper on which prints are made is sensitive to light, much as our film was sensitive to light. There are two kinds of printing-paper, which will be fully described, one of them a good deal more sensitive to light than the other. The first, called Velox (which is the best-known gaslight paper), is sufficiently sensitive to be printed by gaslight or other artificial light at night; the second, called Solio (which is the chief brand of P.O.P., or *printing-out paper*), can only be printed by daylight.

For our first experiment in printmaking we shall use P.O.P. Procure at the dealer's a packet of glossy Solio of the same size as the negative, a shilling bottle of combined toning and fixing solution, and a printing-frame with a piece of glass free from all faults such as air-bubbles.

If we take one of these pieces of Solio and put it at the window on a bright day it will presently show its sensitiveness to light by turning black. It will not go black in artificial light, and if the daylight is very faint it will take a long time to go black. The amount of direct daylight reaching the back part of a room, some little distance from the nearest window, is small, so we may open the Solio packet quite safely at the back of any ordinary room, though even there we should not leave pieces of Solio lying about. As soon as we have taken the one piece which we require out of the packet, we should wrap up the remaining ones, and put them back in their envelope.

How the Print is Made. A moment's reflection will show the reader how a positive—a print—is to be made from the negative. If we lay down the piece of Solio behind the negative, and let the light shine through, the Solio will automatically be transformed into a negative of the negative, for more light will reach it through the *shadows* (the transparent parts of the negative) than through the *high-lights* (the opaque or more or less opaque parts).

In our portrait, for instance, we see in the negative that the sitter's white linen collar looks black. Very little light will get through the negative's image of the sitter's collar on to the Solio; consequently that part of the Solio which is under the collar will remain unexposed to light—will remain white. Under the sitter's chair there is a dark shadow, which in the negative is light, almost transparent. A good deal of light will get through this part to the Solio, which will therefore darken, and thus delineate correctly the darkness of the shadow. Throughout the whole scale of multitudinous lights and shades the Solio will capture every gradation, provided the negative contains that gradation, but always in negative—which, as we pointed out, means that the negative of the negative will look to our eyes a positive.

The printing-frame has some resemblance to a picture-frame, opening behind by means of a pair of sliding springs. Unclasping those springs, and taking out the back, we see a piece of glass, on which the film negative can be laid down. Against it the piece of Solio can be laid, the back replaced, and the whole sandwich of glass, film, paper, and back clamped securely. Put down the negative on the glass with the film side—that is, the dark, dull side—face upwards, and the shining side against the glass, first of all seeing that the glass is polished clean. On the negative put the piece of Solio face downwards—that is, with the glossy side against the negative's film or dull side. Now put in the back, and slide the springs home. The printing-frame is now taken to the window, and

PHOTOGRAPHIC STUDIES IN THE OPEN AIR

A TRAWLER

A DUTCH MILL

A SCHOONER

A STUDY IN MOVEMENT

THE OBSTACLE

COMRADES

THE WATER-TROUGH

SEA-FOAM

put up there, either on the sash or on the sill outside, in such a manner that clear, uninterrupted daylight floods through the front of it, through the glass and the negative, to the Solio behind.

The Treatment of Thin and Dense Negatives. If the negative is a very black-and-white-looking one—a negative in which the dark portions are exceedingly opaque and the other portions very transparent—it is called a contrasty or *hard negative*, and it may be printed in direct sunshine. In this case some little care must be taken to put up the frame at the window (preferably outside the window) so that no shadow falls upon it. The shadow of the window-sash, or of an upstanding tree or steeple or fence rail, falling half across the frame will cause that part to be slower in printing than the rest. The frame should face direct towards the sun, so directly that not even the rebate round the frame casts a shadow along the margin of the glass.

Ordinarily, however, with an average negative the most pleasing results are obtained by printing not in the sun, but in the shade. Not that the printing-frame is to be put in a dark shadow. It should be put out, if possible, on to a window-sill, or some such place, where it can lie, glass upwards, facing the open sky, but not in the direct rays of the sun.

Just how long the printing will take it is impossible to say. In bright weather, or with a *thin* —that is, not very opaque—negative, printing may be complete in a few minutes. In dull weather, or with a *dense*—that is, extra opaque—negative, printing may take hours. Fortunately, it is possible very soon to judge about what the duration of the printing will be. If the light is bright, we may take down the printing-frame a few minutes after we have put it up on the sash or sill, and carry it to the back of the room to examine the Solio. It is not wise to examine the Solio at or near the window, for fear bright light might reach it and fog its picture. If printing has begun, on lifting up one half of the hinged back, and turning back the paper, we shall now see on the paper a more or less faint positive—a picture of the portrait which we took in the garden. If, as is likely, the print is not nearly dark enough, we let it relapse into place again on the negative, close the back, and push home the spring, then putting out the frame into the daylight once more. During printing we can examine the sheet of paper any number of times, provided we take care to do so in a subdued light. By examining it at short intervals (or long intervals, if the day is dull and the progress of darkening slow) we shall be sure to catch it at the point when it is enough printed and not too much. A print which is too much printed is too dark, and is irretrievable; nothing, too, can be done with a print which is too light. It must be right—not too dark and not too light.

Depth of Printing. As it is to undergo toning, during which it will lighten somewhat, it must be printed a fraction darker than we desire it to appear when finished. How much darker it must be printed can only be learnt by experience, but the beginner will soon have discovered, and thereafter need make no mistakes.

When the print is dark enough—that is, very slightly darker than would be desirable when finished—it may be removed from the frame (again working at the back of the room), and we shall now see that it is a reddish or purple hue all over, something like the curious colour made by an indelible or "copying-ink" pencil. The chemical changes to which it must be subjected will alter that hue to a more pleasing one. Their more important object, however, is to render the print permanent—that is, immune from spoiling by light. For obviously the print as it stands now is capable of still further darkening; and if we let it see much light, it will gradually become so black that the picture upon it will vanish altogether.

Toning and Fixing the Print. We have to do to the print what we did to the strip of film negatives after development—we have to fix it. Incidentally, while fixing it, we may change its colour to one which is more pleasing than its present one. For this purpose we must use the combined toning and fixing solution. *Toning* means altering the colour of a print. The colour is called the "tone"—a brown tone, a purple tone, and so forth. *Fixing* means taking out of the print the chemicals which render it sensitive to light.

If the dish which we used for fixing the film negative has been scrupulously cleaned, it may be used for toning and fixing the prints. Better still is to obtain another dish, also a deep porcelain one, and to keep it reserved for toning and fixing, while the fixing-dish for negatives is similarly reserved for its own special purpose. Half fill this dish with the toning and fixing solution. Should there be any sediment in the latter, no notice of it need be taken. Another dish or bowl of cold clean water, and a towel, should be handy.

The print is taken, holding it by the edge of one corner, and slid into the dish of toning and fixing solution, face upwards. It must be slid smartly and steadily, without any hesitation and without any splash, so that it is submerged as nearly as possible instantaneously. If it does not go under the surface of the solution completely, the dish should be rocked, so that a small wave of solution flows over the face of the print. It is important that the print should be covered as evenly and quickly as practicable, otherwise it will display irregular markings, for the solution gets to work upon it at once. The print's glossy surface is really a coating of gelatine, and this gelatine (like the gelatine on the film) absorbs the solution, which acts upon it in various ways. The only visible action is the toning—the changing of the print's colour. Should this toning be patchy, the effect will be very unpleasant; in fact, the picture will be spoilt.

Avoidance of Uneven Toning. The dish is rocked gently in order that the print may be kept submerged. Soon after its immersion the wetting may cause the print to curl up at its edges, these latter consequently rising out of the solution. Should this occur, the print, held by its extreme margin, may be lifted out of the dish bodily, nd slid in again face downwards, so that its back may be thoroughly wetted and any clinging air-bells dislodged. Do not leave the print in the solution face downwards; it should only be plunged in face downwards for a moment, then withdrawn and put back face upwards. After this, it ought to lie flat; but to keep it evenly submerged by the solution we may continue to rock the dish.

When the beginner becomes more at home with his materials, he will learn to tone and fix two or three prints simultaneously, one on top of the other, in the same dish. At first he should certainly only tone one at a time. In toning more than one at a time, it is very likely that they will stick together, and toning will be uneven.

Should parts of the print show a tendency to rise above the solution or float on it, these may be very gently pushed under by a finger-tip, if the finger is

NATURAL BEAUTY RECORDED BY THE CAMERA

WAYSIDE COTTAGES

THE WOODLAND POOL

IN AN OLD GARDEN

All the photographs illustrating this article are supplied by courtesy of Messrs. Kodak, Ltd.

absolutely clean and if the pressure exercised is cautious. Better still is to use one of those little instruments called a print-paddle, obtainable at the same shop as the Solio ; or the print may be pushed down with the glass stirring-rod if the latter is subsequently cleaned. Touch the surface of the print as little as possible, and never proceed to further printing, during which it will be necessary to handle dry sheets of Solio, without first washing and drying the hands if these have been soiled with the combined toning and fixing solution.

Almost immediately after being placed in the solution the print will probably alter from its pinkish or purplish colour to a disagreeable mustard-yellow. This presently gives place to a warm reddish-brown ; the reddishness gradually leaves the brown, and a pleasant pure brown remains. Should the print be left longer in the combined toning and fixing solution, it will arrive at a kind of pale purple colour, but in general it will be found that the toning is best stopped when the pure brown stage is reached. The print, however, ought not to be taken out of the solution while any redness remains. By lifting up the print and looking through it at the light, we can sometimes judge better whether the brown is through and through or not, rather than by looking at its face. All these operations can be carried out in a good light, but not quite at the window of the room. But once the print is into the toning and fixing solution, it has ceased to be liable to rapid darkening from exposure to light, and we need take no great trouble to shield it, though we should be unwise to let the dish stand in a flood of sunbeams.

Washing the Print. When the print has reached a stage of brown which pleases us—it is purely a matter of personal taste ; only the print should certainly not be taken out of the solution in less than five minutes, and should preferably remain in it for ten—we can lift it out of the dish, allow it to drip into the dish for a moment, and then plunge it into the vessel of clean water which we placed ready at the beginning of our experiment.

No further change will now take place in the print, as far as its appearance is concerned, but it must be washed —as the film had to be washed—in order to get the chemicals of the toning and fixing solution thoroughly soaked out of its gelatine. If this were not done, the picture would fade or stain when dry. The print may be washed by being given a number of changes of clean cold water. If the cold tap is allowed to run into a bath until the latter is 18 in. or 2 ft. deep in water, and the print, pinned by one corner to an old cork, is allowed to float therein, it will wash itself ideally. It must soak thus for an hour or an hour and a half ; by that time all the remains of the toning and fixing solution will have been washed out of the paper into the bath water, and sunk to the bottom. Floating clips may also be used for suspending prints in the bath.

Other prints may be made similarly, and toned one after the other in the same dish of combined toning and fixing solution, then put to float, attached to corks, beside their fellows in the same bath. After a good deal of use, the toning and fixing solution will grow muddy, and slow in its action. It should then be thrown away and a fresh bottle bought. But when only used for a few prints, the combined toning and fixing solution need not be thrown away ; it can be poured back into the bottle and kept for future use. Always wash out the dish very carefully after it has contained toning and fixing solution. It should preferably be kept solely for toning and fixing, but if used for any other photographic process this must be limited to fixing only. When the dish has been washed, stand it on its edge to dry, back outwards, so that the dust does not lodge inside it.

At the end of an hour or an hour and a half, the now washed print may be taken out of the bath, unpinned from its cork, and pinned by its edge to a clothes-line to dry, or pinned to a shelf, where it hangs so that the air can reach both sides of it. It should not be dried between blotting-paper.

Gaslight Printing. Velox paper, which is the alternative printing process to be described here, is very much more sensitive than Solio, and can consequently be printed by artificial light. Printing can therefore be done at night. The results, too, differ in appearance from those on Solio. Velox prints are of a pure black hue, while Solio prints are brown. Should our negative happen to be a flat one, Velox will further have the merit of giving us a somewhat brighter type of print than Solio. Various brands of Velox paper are to be had, in sixpenny and shilling packets, but for our first experiment we shall choose the kind called "Art" Velox. This gives prints of a pleasing semi-matte surface

For Velox printing we require a bottle of Velox developer and a tin of the same acid fixer as we used for fixing our strip of film. We must also obtain a couple of dishes, preferably of the same porcelain make as we chose for fixing and toning. One of these dishes should be the correct size for the print—that is, if our photographs are quarter-plate size, buy a quarter-plate dish, and so on. The other dish may conveniently be larger, or we may use the dish which was employed for fixing the film. The smaller of the two dishes is required for developing the Velox print—for Velox resembles film in that the image upon it is invisible after exposure, and can only be made visible by development.

When printing the Solio we are able to judge the progress of printing by examining the print from time to time and observing the depth of the image. This is impossible in Velox printing. The exposure of the Velox print has to be guessed in much the same manner as we guessed the exposure of our original snapshots. This does not mean that making a Velox print is really any more difficult than making a Solio print. In many respects it is easier and pleasanter, as a trial will show.

To make a Velox print we require a printing-frame—the same one which we used when making the Solio print. The frame, however, is not put up at the window to see the light—it is exposed to gaslight or electric light or lamplight, and this must be done at night, not during the daytime. It is possible to make Velox prints by daylight, but the beginner is not recommended to try it.

The room in which we are going to make Velox prints should have the lamp at one end of it and our work-table at the other. If the work-table must be near the lamp, the former should be screened from direct rays. If no direct rays fall on the work-table there is hardly any risk of fogging the Velox paper when opening the packet. Place the printing-frame, with the negative in it, at one end of the table, together with the packet of Velox, which for a start had better be the " Vigorous " grade.

Farther along the table—sufficiently far off to be certain that no splashes could reach the frame or the Velox—place a measure-glass containing the Velox developer. This latter is generally diluted with an equal quantity of water. The directions

on the label of the bottle must be followed faithfully. Do not be induced to try any developer but that sold specially for this paper, as developers made for "bromide" papers (which somewhat resemble Velox) do not give such good results. Beside the measure-glass is the smaller of the two dishes—the one intended for developing. It must be scrupulously clean. No amount of care is too great to take to see that none of the fixer gets into the developing-dish.

Next to the developing-dish there must be placed a bowl containing clean cold water, and next to this bowl is the fixer dish, which is half filled with the solution of the salts found in the tin. Do not be economical of fixer. It must be made up fresh for each batch of Velox prints; and it and the developer ought to be as near as possible to a temperature of 65° F. A test with the thermometer is worth while if there is reason to suppose that either of these solutions is too cold. If this turns out to be the case, the solution should be warmed—enough, but not too much. A clean towel must be kept handy, for in Velox-printing cleanliness of the fingers is of perhaps even more importance than in the other photographic processes. Everything is ready now, and we can open the envelope of paper and take out a sheet. This must not be done in the direct rays from the lamp; and as soon as one sheet has been removed for use the remaining ones should be wrapped up, or placed in a light-tight drawer.

The beginner who has never handled Velox before may possibly find a little difficulty in detecting which is the sensitive side of the paper and which is the back, for of course, like Solio, it is coated on one side only, and the coated side must be placed against the negative in the printing-frame. Art Velox is readily distinguishable even in a faint light, for its coated side is perceptibly shinier than the other. But if the photographer is in doubt he may recollect two tests for the coated side. The first indication is that the paper always has a slight tendency to curl with the coated side inwards. If no curl can be observed, the second test may be applied. Take up the Velox by its edge, and place the other edge between the teeth, bite upon it, and the coated side adheres momentarily to the teeth. Do not breathe on the paper while doing this. Having found the coated side, lay it face downwards on the negative in the printing-frame and place thereon the back, clamping the springs home.

The Position of the Light. The exposure is to be made by holding up the frame in front of the lamp. But as the exposure is a matter of a few seconds only, and as the light of the lamp does not carry far, it is obvious that the distance at which the frame is held from the lamp must be settled with precision, not left to chance.

In practice the frame should be held as near the lamp as will ensure the negative being evenly illuminated all over. Should we push the printing-frame close up to the lamp, the negative will be illuminated more brightly at its middle than at its edges, and the resulting print will have a spot of fully exposed detail in the centre and a falling off of detail all around. It is a rough rule, but a sound one, that the distance of the printing-frame from the lamp should be approximately equal to the diagonal of the negative. A 5 in. by 4 in. negative, for instance, should be exposed at a distance of, say, 6½ in. from the lamp.

Six or seven inches is a safe, useful distance to choose for all negatives of the usual small sizes. Before beginning to make Velox prints, it is well to measure off 6½ in. from the lamp; and a good plan is to tie a piece of string with a knot in it so arranged that, when the knot is held in the hand which grasps the printing-frame, the latter must be precisely 6½ in. from the light. In gaslight-printing this is easy, as the string may be attached to the gas-bracket. When printing by a standard electric lamp (which is the most convenient) the string may be tied to the standard. If a hanging electric bulb is used, the 6½ in. from its bottom should be measured and memorised—thereafter being judged by eye. The frame has, at all events, to be held at (we shall suppose) 6½ in. from the lamp, so that the light from the latter streams through the negative and on to the face of the Velox paper which is lying in contact with it behind. This is "exposure," and of course the question at once arises: How long should the exposure be?

Duration of Exposure. And this is precisely what it is impossible to answer off-hand. It all depends on the strength of the lamp and the density (that is, the darkness) of the negative. It is plain that if the negative is very dark the light will have more difficulty in getting through it than if it is less dark; and it is plain that more light will get through the negative from a powerful lamp than from a poor one.

The consequence is that the first exposure must of necessity be a guessed one. Subsequent ones, based on a knowledge from the first, need not be in the nature of guesses; and indeed the first itself will as likely as not turn out to be correct. In the leaflet of directions which accompanied our envelope of Velox some experimental exposures are suggested; and one of these, if tried, will probably produce a perfect print. With a bright, sixteen-candle-power electric bulb we may for a start guess that fifty seconds' exposure will give us a good print. This, be it noted, is on the presumption that we are using the "Vigorous" grade of Velox and placing the frame at 6½ in. from the lamp.

Taking up the printing-frame from the table, on which it has been lying face downwards so that no light should reach it before it ought, we move it quickly forward to a point 6½ in. from the lamp, and at once look at our watch and note the position of our seconds-hand. Accurate measuring of the time is essential, and a watch with a seconds-hand should always be used. If one is unobtainable, the photographer may count seconds for himself; but in that case he will do well to note that a second is of longer duration than he has perhaps supposed.

A simple and practical dodge for measuring seconds, which finds favour with many of the photographers of the old school, and may wisely be adopted, is to count audibly not "one," "two," "three," etc., but "one-hundred-and-one," "one-hundred-and-two," "one-hundred-and-three," and so forth. Seconds counted in this way are generally exceedingly accurate, while seconds counted separately, with a pause between each number, are inaccurate in duration, except when spoken by highly experienced workers. It is the pause which makes the measurement wrong. Velox paper has such latitude, however, and is so easy to use, that the minute errors which any beginner makes in the matter of exposure will probably not be discernible, even on his earliest attempts.

During the fifty seconds the frame should be very slightly moved up and down and from side to side (a mere couple of inches each way) to ensure that the lamplight is reaching it evenly all over. The moment the fiftieth second is up, we withdraw

the frame smartly and take it back to the table, where we lay it face downwards again. Opening the back of the frame, we lift out the sheet of Velox. Its front betrays no trace of a picture. The image thereon is latent—as was the image on our strip of film before we developed. Take up the Velox with care. It should be gripped by the extreme edge, and on no account should a finger-tip touch its face, or ugly markings will inevitably ensue.

Development. Lay the Velox face upwards in dish No. 1—the developing dish—and, taking the measure-glass of developer in the right hand, pour the developer, in one swift, smooth wave, on to the sheet of paper. The latter must be instantly submerged all over; and the dish is promptly rocked, so as to cause the developer to flow to and fro on its face. If the piece of Velox has been correctly exposed, the picture will appear at once, very quickly gaining in depth, until in about fifteen or twenty seconds it is as dark as we want it to be. No amount of further developing will cause it to go any darker. If it is too pale, the exposure has been insufficient, and we must make another trial, giving a longer exposure. If the print is very pale indeed, the exposure may have to be doubled or even trebled; if it is only not quite dark enough to be satisfactory, an exposure half as long again should suffice. On the other hand, if the print flashes up in the developer, and with great rapidity becomes too dark to be pleasing, the exposure has been too prolonged, and the next exposure must be shortened by judgment.

Fixing the Print. In some fifteen seconds or so, then, the Velox print may be removed from the developer. This should be done by gripping it, as before, by its extreme edge or by one corner. It is lifted out of the developing-dish and immediately dipped in the bowl of water which stands beside it. One swift dip in the bowl of water suffices to remove from its surface the clinging developer, and it is without an instant's delay slid into the fixer.

It is of the utmost importance that the print, while in the fixer, should be thoroughly submerged. If it shows signs of being inclined to float on the top of the fixer liquid, the latter should be quietly rocked until the print sinks. If it refuses to sink, it should be pushed under the surface, gently but firmly, with a glass rod or toothbrush-handle, or, better still, with a print-paddle. Should any part of the print lie above the surface of the fixer for a minute or two, and thus be exposed to the air, that part will subsequently show stains, generally of a disagreeable, rusty colour.

Washing. The print should remain in the fixer for not less than fifteen minutes. Thereafter the fixer is washed out of it in the manner described for films and for Solio—by floating in the full bath, pinned to a cork. Or the print may be washed by being transferred from one dish of water to another, a dozen times or so, the water in each dish being changed at each transference. When thoroughly washed, the Velox print is dried by being hung in the air like the Solio print. Meanwhile all dishes are scrupulously cleansed as before.

Both Solio and Velox prints are apt to show a disposition to curl a little when dry. The curl may be taken out of them by placing them under pressure, but a better method is to take a ruler, or some other flat-edged object, and pass the prints under it in such a manner as to impart to them a reverse curl, to counteract the original one. The print, that is to say, is laid face downwards on a piece of clean cardboard or other smooth surface, and the edge of the ruler pressed lightly above. Draw the print under the ruler-edge so that the former is caused to drag along the cardboard and be turned upwards as it emerges from this pressure. Two or three pulls under the ruler will straighten it out absolutely flat.

The same method of flattening applies to post-cards, which also curve inwards. Here it may be remarked that the treatment of postcards is the same throughout as that of paper prints.

Trimming the Print. The finished print is surrounded by a margin of white or black, due to the overlapping of the rebate-mark of the negative or the edge of the printing-frame. This margin is of no consequence if the print is to be placed in a "slip-in" album, whose openings in the leaves are of such a size that they automatically have the effect of trimming or framing the picture. Ordinarily, however, we shall want to cut off the margins, to make a neat job of our picture.

This cutting off of the margins, called trimming, may be done with care by using the point of a sharp pocket-knife guided by a straight-edged ruler, the print meanwhile lying face upwards on a backing of cardboard or a pile made of sheets of old newspaper, To cut the corners true by this means is, however. none too easy to the beginner, and he will be wiser to invest in a little appliance named a print-trimming board, which is squared true, and furnished with a guillotine blade and handle. The print-trimming board costs a trifle, and trimming pictures by its aid is rapid and pleasant.

Mounting. Various methods of mounting the print are in vogue, and are too detailed to be described here. The simplest is the *dry mounting* system, with the apparatus for which are full instructions. *Mounting-tape*, which is a strip of paper with adhesive on both sides of it, is also useful, and should be brought to the notice of the amateur who does not wish to go to the expense of the dry-mounting materials. Mounting-tape, correctly used, entirely supersedes the old-fashioned, messy method of mounting with paste. Paste-mounting, in fact, except in the hands of the most dexterous workers, is so unsatisfactory that we shall not deal with it. The amateur who wishes to escape the labour of mounting altogether will prefer, at any rate, to purchase mounts or albums ready-made with prepared openings of the aforementioned "slip-in" variety. These have the further advantage that the prints in the mounts or albums need not remain there permanently; they may be changed as often as wished.

The foregoing pages have dealt with photography as it is practised by the great majority of amateurs—those who photograph because they want to make pictures of the things they see, and to make these pictures with the minimum of effort and trouble. But there are some on whom the pastime grows until the means becomes more fascinating than the end—the taking and the making are frequently more important to them than the resulting photograph. They become what are generally known as "serious" photographers. They do not mind carrying heavy and fragile glass plates instead of the light and unbreakable Kodak film. They do not mind having to spend hours in dark-rooms working at different processes.

It must not be thought from this that the Kodak is not used by advanced workers. Many of the finest pictures shown in the exhibitions are enlarged from film negatives taken in Kodaks.

The Bare Land and its Preparation. Laying out the Useful Garden. The Kitchen Garden. Hedges, Walks, Lawns, and Beds, Rock, Water, and Wall Gardens.

THE GARDEN BEAUTIFUL

BETWEEN the wide expanse of pasture land which it is proposed to transform into a market garden, or beautify as an adjunct to a mansion, and the tiny plot of the suburban house, covered with builders' debris and overrun with weeds, there does not, at first sight, appear to be much connection. Yet, vast as the science of horticulture is, the same principles can be applied, with certain modifications, to the garden of the millionaire and to the tiny pot-plant struggling for life on the window-sill of a city slum.

It may appear superfluous to remark that anybody who desires to attain a knowledge of gardening must begin at the beginning, but there is a reason for saying so. Buying plants from a nursery in the springtime and putting them in the ground is not gardening, any more than paying a man to do all the hard work is, and, therefore, to acquire proficiency in horticulture, a novice must go right "back to the land" in its original condition.

The First Step in Gardening. The first step to be taken is to find out the nature of the soil one has to deal with. The chief constituents of all earth are one or more of the following substances in various proportions—clay, sand, gravel, lime, and decayed vegetable matter. Take a spade and turn over a few spits (a spit is a layer of earth the depth of a spade's blade) of the soil on the land or garden it is proposed to cultivate. Dig down to some little depth, as the character of the soil often varies somewhat two or three feet below the surface.

Now examine a spadeful of the earth. If it be thick and "stodgy" with clay, it is what is called a heavy soil, and will need a good deal of improving. If it contains a fair amount of sand mixed with clay, so that it is not sticky and sodden, it is a natural loam, the most precious of all soils to the gardener. Should there be so much sand, however, as to make it dusty and crumbly, it is known as a light soil, and wants careful handling. Where a large amount of chalk enters into the composition of the ground, as in many parts of Kent, and on the Surrey hills, the soil is called a calcareous one, and in its natural state is specially suited for the culture of many sorts of vegetables. The richest of all soils, though not the most useful for general purposes, is peat. This may be distinguished by its very dark colour, and the presence of decayed vegetable matter. It is met with most frequently in damp situations, and really represents the first stage in the transformation of vegetable matter into carbonaceous matter.

Draining and Levelling. When once the nature of the soil is known, it must be drained and levelled if the area is of considerable extent. Town and suburban gardens are, of course, already drained, and are generally of such limited area that they require no levelling. A simple and effectual way of draining is to dig a series of narrow trenches, six yards apart, from the highest points of the ground to the lowest, laying at the bottom of these trenches, which should be 3 ft. or 4 ft. deep, so as not to interfere with the roots of plants, a row of common earthenware pipes 3 in. in diameter. These must communicate with a larger, or main, drain pipe, which empties itself into a pond or stream, if one exists, or, if not, forms the nucleus of a pool, which, by this easy and natural process, becomes an admirable site for the water garden.

It is not necessary to give much attention to levelling a garden. The need for it is non-existent in the small suburban garden, and, as far as the market garden is concerned, levelling is a waste of money and time, except when sites for rows of glasshouses have to be prepared. For this purpose, however, and also for the formal part of the garden near the mansion, and in the preparation of tennis lawns, bowling greens, and other flat ground, some levelling must be done.

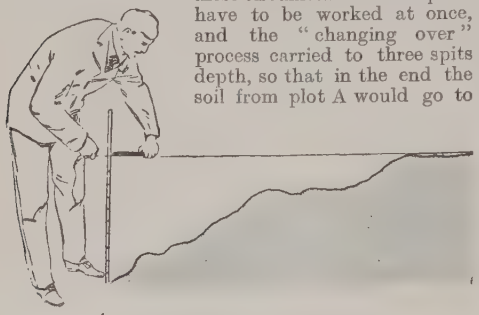
How to Level the Garden. This can be accomplished by very simple means. A peg, a length of cord, a stick marked with feet and inches, and a spirit-level are all the implements that are required. At what is judged to be the highest point of the ground to be levelled, a peg, with the cord attached to it, must be firmly driven in. Thence the cord must be extended over the whole area until the lowest point is found. This is done by sliding the loose end of the cord up and down the measured stick at various points [1] until, by means of the spirit-level, the difference between the highest and lowest points of the ground is discovered. For the sake of illustration, suppose this to be 4 ft. Therefore it is necessary, in order to establish a common level, to throw 2 ft. of the soil from the highest part of the land on to the lowest part.

In practice more than this must be done, and the low parts to be filled should be built up to at least 6 in. higher than the spots from which the earth is taken, to allow for subsidence, and also for compression when the roller is applied.

Digging and Trenching. The question of removal of soil brings us to the all-important subjects of digging and trenching. Digging is, of course, the simple act of turning over earth with a spade, but trenching is a term which the novice will need to have explained to him. Perhaps the definition given by J. C. Loudon, one of the greatest authorities upon gardening, is the simplest: "Trenching is a mode of pulverising and mixing the soil, or of pulverising and changing its surface, to a greater depth than can be done by the spade alone." This changing about of the soil in a garden is necessary for the purposes of aerating and sweetening it, as earth which is left too long undisturbed is apt to get foul and stagnant.

The simplest form of trenching is what is known as two-spit, or bastard trenching. Let us call two parts of the garden A and B. First the top spit and then the second spit of A are removed to a neutral spot, and the same is done with B, keeping the respective spits separate. Then the top spit of B is placed where the second

spit of A was, and the second spit of B put on top of it, while the top spit of A is placed at the bottom of plot B, and covered with the bottom spit A. In other words, the soil in the two plots A and B is taken up, turned upside-down, and made to change places [2]. For many gardens, especially suburban ones, where, as a rule, the soil is shallow and rests on a solid bed of clay, this form of trenching is sufficient, but where the soil is deep the operation of trenching is more complicated. In these circumstances three plots have to be worked at once, and the "changing over" process carried to three spits depth, so that in the end the soil from plot A would go to



1. LEVELLING THE GROUND

C, from B to A and from C to B, but inverted, so that what was once the top spit of A would be the bottom spit of C, and so on.

The Nature of the Soil. During the process of trenching, which may well be carried out while levelling is going on, much improvement can be effected upon bad soils. They may, first of all, be rendered more workable by causing the stones and pieces of brick to be picked out. Such refuse is generally to be found in a garden attached to a new house, where the builders' men have buried it in order to avoid the trouble of carting it away. These pieces of bricks and stone should by no means be discarded, but placed at the very bottom of the trench when levelling, in order to assist drainage.

The drawback to a heavy clay soil is that, being impermeable, it will not allow the rain to pass away, and, as a consequence, gets very sour. It is obvious, therefore, that anything which will tend to lighten or break up this heavy clay will be of advantage. This being the case, the autumn is the best time to commence the formation of a garden. The ground should be trenched as already described, and left as open as possible. Then, when the winter frosts come, the water which the clay contains will freeze, expand, and to some extent force the particles apart to admit air, and thus the soil will become somewhat more open and workable by the time the springtime arrives.

Manure. In these early stages the only manure, if any, which should be applied is a layer of horse manure, with plenty of straw. This should be placed at the bottom of the trenches—that is, after the earth has been dug out, and before it is replaced. Though this does little to lighten the soil, it increases its fertility to some extent.

Before beginning digging operations it will probably be found necessary to clear the ground of weeds and long grass. None of this refuse should be thrown away or wasted, but carefully stored and thoroughly burned, and the ashes dug into the ground. This process should be repeated at intervals with anything in the shape of rubbish that is capable of being burned. It is well, however, to change the situation of the bonfire each time, even as the heat and the action of the flames on the earth are beneficial to a heavy soil.

Road sweepings, with the grit they contain, are of great value under certain circumstances. This remark applies chiefly, however, to the sweepings of country roads. Recent developments of motor traffic, and constant droppings of oil refuse, have rendered the road sweepings of town streets of comparatively very little garden value.

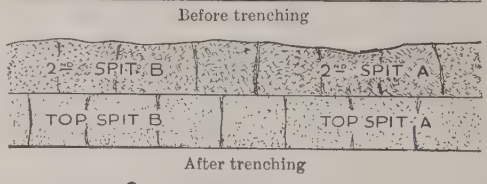
It is not sufficient merely to deposit the ashes, grit, and other lightening materials upon the ground. They must be dug over well and constantly until they and the soil are thoroughly well mixed up, as otherwise no beneficial results will be obtained.

Improving the Soil. By dint of patient and constant work it is thus quite possible to turn what was once regarded as a hopeless mass of clay into a fairly open, if somewhat heavy soil, while the presence of clay underneath at a depth of from 2 ft. to 3 ft., according to the distance trenched, is an advantage rather than otherwise, as it retains the moisture during the hot summer months, and so enables the roots of the plants to keep cool and prevents them being parched.

Improving a soil which is too light or sandy is not such an easy matter as improving a heavy one. The process may, of course, be reversed, and some clay introduced to thicken the ground, but the mixture rarely proves to be a satisfactory one. To make the best of a very light soil, it is necessary to trench it very deeply and openly before planting in the spring. This has two beneficial results. As the soil is thus rendered loose, the roots of plants can easily penetrate to a great depth in order to get at the moisture which is so necessary for their welfare; while, on the other hand, this treatment allows the rays of the sun to penetrate the ground freely, and so draw the moisture towards the surface.

When once the operation of trenching has been carried out, it is better temporarily to discard the spade for the garden fork in turning over the soil. Lumps of clay can be broken up more finely with a fork than with a spade, in addition to which the operation is not so fatiguing to the worker.

Foreign Elements in the Soil. In the course of these digging and forking operations, many large stones are sure to be met with. These should all be removed and set aside, as they have their use. They may be used to form the basis of a rock



2. TWO-SPIT TRENCHING

garden, which is described in more detail later; or, if too small or misshapen for this purpose, can be added to the contents of the bottom of the trench, as mentioned above.

Occasionally it happens in the course of digging that what appears to be a reddish-brown "vein" is struck. If this occurs, immediate action should be taken, as it indicates the presence of iron in the soil. Now, iron in a soil has a great tendency to render it

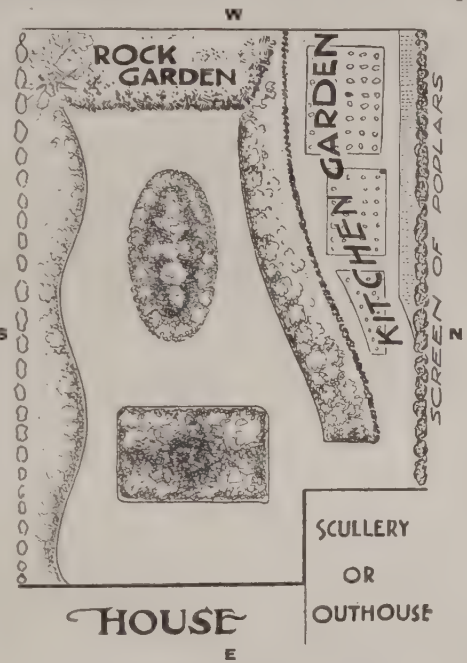
unproductive, so that prompt treatment is necessary, and a dressing of lime should be dug into the affected part. The iron is invariably in the soil in the form of an impure sulphate, and the lime combines with the sulphuric acid in the iron sulphate, and forms sulphate of calcium, thus sweetening the soil and eliminating the dangerous compounds.

Magnesia, manganese, sulphur, phosphorus, soda, and chlorine are all found in varying proportions in soils of different natures. Where they do not occur naturally, and are required for the welfare of one plant or another, they must be supplied by artificial means, and this is the fundamental principle of chemical manuring, of which more will be said.

LAYING OUT THE GARDEN

Before beginning to lay out a garden it is obviously necessary to decide what sort of a garden is required. There is the garden for pleasure only, which is a flower garden pure and simple; the garden for profit—as distinguished from a market garden—the owner of which has merely an eye to the abolition of greengrocers' and fruiterers' bills; and the general purpose garden, which is a combination of the two, and is the garden usually met with, as well as the most useful.

The majority of very small town and suburban gardens are unsuited for the culture of fruit and vegetables, with the exception of a few kinds, and must, perforce, be gardens for pleasure only; but there is no spot, however barren and smoke-ridden it may be, which will not lend itself to gardening of some sort. In cities and towns a good guide as to what may be grown with reasonable chance of success will be found in a visit to the local park, and a study made of what flourishes therein. In very smoky spots the secret of success is to water the foliage of plants freely, in order to wash away the particles of soot which accumulate.



3. PLAN OF A SMALL GARDEN
Showing kitchen garden and screen of poplars

The Aspect of the Garden. The very first thing that should be done with a piece of ground which has been levelled for gardening purposes is to determine its position with regard to the points of the compass. An ideal garden of moderate dimensions is oblong in shape, with the long sides facing north and south, while the house is at, and facing, the east end of the plot. In such a position the building protects the contents of the garden to a considerable extent from the cutting east winds, while there is a good expanse of south wall for the culture of fruit. Many a fruit-tree or half-hardy plant, which would die of exposure in any other situation, will thrive on a south wall, or in the border at its foot. Moreover, a south wall gets the benefit of the sun for the whole of the day, in summer and winter, and is its own protection from north winds. The terms south, north, and so on, when applied to walls in gardens, do not mean that they are situated in that particular part of the ground, but that they have a southern or northern aspect, as the case may be.

The novice visiting a garden of any pretensions for the first time frequently wonders why it is situated at one side of the house instead of at the back. It is just this question of exposure to sun and winds from different quarters that has provided the reason, and the same rule holds as good for the 12-ft. patch as for the nobleman's broad acres. The worst position of all for a garden is one in which the house faces west or south-west, as the garden has practically no shelter from the icy blasts from east and north. In laying out such a garden, therefore, plants of the most hardy nature must be chosen.

One of the first questions which will enter the would-be gardener's mind, as he stands at a back window and contemplates the waste which he is to make fertile, is: "How much of this ought I to devote to fruit and vegetables, and how much to flowers?"

A great deal depends upon local conditions. If the district is one well furnished with markets in which fruit and vegetables are procurable at reasonable rates, it is better to devote the bulk of the space to floriculture, reserving a little for the choicer products of the kitchen garden. If, on the other hand, vegetable produce is dear, and, as is often the case in country districts, consists chiefly of inferior local varieties, it is wise to make the kitchen garden at least half of the total area. This remark applies to gardens from which it is hoped to derive both pleasure and profit.

The Kitchen Garden. Having decided what proportion of the ground to be laid out is to be devoted to kitchen garden purposes, the next step is to mark it off and divide it from the flower garden. Useful though they are, vegetables grown, as they should be, in symmetrical rows, like regiments of soldiers, are not a particularly alluring prospect in a garden landscape, and it is usual to separate this portion of the garden from the pleasaunce by a hedge of some description—a subject to be dealt with later.

In the smaller gardens it is usual to find the kitchen garden consisting of a corner lopped off indiscriminately from whatever part of the ground happens to be situated at the farthest point from the house, irrespective of situation or aspect. This is a mistake. The question of aspect is just as important for the successful culture of fruit and vegetables as of flowers, and, speaking, as a rule, in the case of the orthodox oblong garden, the vegetable portion will best repay attention if it is formed of a strip running parallel with the flower garden for practically the whole length of the ground. It may

be stopped within a few yards of the house or eased off into nothingness, so as to give the broadest expanse of bed or lawn near the house [3].

If a very large garden is in course of preparation the kitchen garden is, of course, a thing apart, and is kept away from the flower garden altogether. In these cases a position on a southern or western slope is usually assigned to it if such be available, but the laying out of places of such dimensions is not usually entrusted to an ordinary head gardener. A specialist, known as a landscape gardener, is invariably called into requisition, and the resident gardener and staff work upon the lines which he lays down.

Improving the Aspect. Though the question of aspect is one of the utmost importance, a good deal may be done to improve a bad situation. Where a garden is swept by east or north winds, a screen of trees, such as poplars, will assist matters materially. Certainly, unless large-sized trees are obtained in the first place—and this is a somewhat costly business—some time elapses before the benefit of their presence is felt; but when once established, the advantage they offer is permanent. It should always be borne in mind, however, that on no account should a screen of trees be placed close to a house. In the first place, if the house has any pretensions at all to architectural beauty, the presence of trees, or tall-growing shrubs, in its immediate vicinity will sadly mar its dignity, while, in addition, big trees close to the house should be strongly discountenanced from a hygienic point of view. A house hemmed in by big trees is always damp, and they offer obstruction to light and air. In addition, such a screen of trees naturally has a deleterious effect upon the soil, as it impoverishes it, sucks it dry of moisture, and, with a few exceptions, renders plant life impossible within a considerable radius of its branches.

The Garden Walks. The question of walks and paths and where to put them is one of paramount importance in laying out a garden. At least 90 per cent. of gardens of all kinds in this country are wretchedly undersized little places, and yet the tendency is to reduce the available space in them by the introduction of needless walks, leading nowhere in particular, and serving no good purpose. It is a good plan when beginning operations to draw a rough sketch of the ground, marking upon it the different spots at which the kitchen, rock, water, and other gardens, if any, are to find a place.

Then, starting from the house, decide the simplest and quickest routes by which the different parts can be reached. Here a certain amount of discrimination is necessary. There is no need for the paths to radiate with geometrical accuracy like the spokes of a wheel from the back of the house. A graceful curve, for which perhaps the presence of a tree or a rise in the ground will give a pretext, is not only desirable, but to a small garden will give the impression of increased size. At the same time it is absurd to have a lot of serpentine walks wriggling about the place just for the purpose of conveying the idea of great length, while bisecting and trisecting lawns with walks until they look like a problem in geometry is an equally foolish proceeding.

Grass Walks. Unless a garden is of unusual dimensions, three or four main gravel walks, at the most, will be all that will be required, and, for the rest, let the turf come right up to the beds or borders, so that what would under ordinary circumstances be gravel paths are simply grass walks. There are many advantages to this system. The rich green turf forms a far more beautiful setting for a bed of flowers than a gravel path does. It is easier to keep turf in good order than it is to be continually weeding gravel, and although it is urged as a drawback that turf walks are unfit for walking upon after rain has fallen, this is only the case where they have been improperly drained. Moreover, should it be desired at any time to change the character of a garden, this can be far more easily done in a turfed place than in one where gravel walks, running at different angles, have to be taken up and altered.

Making Beds and Borders. Mention has been made of the words "bed" and "border." A bed is a piece of ground in the garden, prepared for cultivation, but which has no direct protection from a wall, fence, or hedge. A border may be best described as the long strip of earth close up against a wall, fence, or other means of protection. For instance, the strips running round the three walls of the ordinary suburban back garden would be called borders, while the circular plot in the centre, if there is one, would be a bed.

In making a bed, after having decided upon its shape, it is best either to peg the shape out upon the ground with sticks and string before commencing operations, or else plan it out in whitewash, like marking a tennis crease. This will prevent the possibility of a mistake. The simple precaution in making a border is to stretch a string taut between two pegs from end to end to ensure a correct edge, as nothing looks worse than an irregularly shaped border, unless the shape of the wall or garden demands it. If the whole garden is a new one and the ground has been treated on the lines laid above, no other preparation is necessary, but where it is proposed to cut a new bed or border out of an existing garden, the ground must be well worked as advised before planting.

The Front Garden. What to do with the front garden is a great source of perplexity to town gardeners, for it is only near the busy centres that the front garden proper finds a place. Most of them solve the problem by planting laurels and privets, a method which, if it has the merit of simplicity, is certainly not the best possible solution.

Though many flowers might be grown in such situations, particulars of which will be given in due course, there is always the danger of their being stolen; but a much wider range of trees and shrubs is available for town use, which have the advantage, moreover, of not being so greedy or exhausting to the soil as the laurel and privet. Of these, some are evergreen, and include rhododendrons, yuccas, azaleas, aucubas, hollies, and euonymus; while those that are deciduous (lose their leaves in winter) comprise weigelia, ailantus, cotoneaster, philadelphus, mountain ash, sumach, elder, ash, plane, elm, and others of our native forest trees. Collections of some of the different sorts of ivies, too, will be found very useful in helping to beautify the town and suburban front gardens.

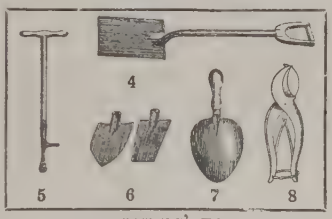
Simplicity should be the keynote of front gardening, and the idea of putting a monkey puzzle opposite the front door and surrounding it at a respectful distance with standard rose-trees is dying out, even as the rhododendron is beginning to oust the laurel from pride of place as a necessary adjunct to such arrangements.

The Rubbish Heap. No matter what the size of the garden may be, a rubbish heap is a necessary evil. It is best to situate it in the most unfavourable part of the garden, and hide it by a screen of privets, or a trellis of woodwork covered by Virginian

creeper. It will naturally be made up of cuttings, trimmings, and all sorts of garden refuse. This should be burned at intervals, and not allowed to accumulate for any length of time, as it breeds and harbours insects. In the summer-time it is a good plan to throw a few spadefuls of earth over the vegetation and allow it to decompose, as such decayed vegetable matter forms a good manure, and will be found of great assistance later in the year.

The Gardener's Tools. The most important garden tool is, of course, the spade [4], which is an implement perfectly distinct from the shovel, although the names are often interchanged, and one tool used for the purpose of the other. The spade is used for digging, and the bottom of the spade should be of steel, and the upper part of iron, thoroughly welded together. Young gardeners often suffer pain, when digging, from the pressure of the foot on the tread, or shoulder, of the spade. This can be obviated by using a little contrivance called a "digging shoe," a sort of anklet of leather which buckles over the middle of the foot, so that there is a good layer of leather acting as a protector where the foot presses on the spade. Spades are made in four sizes—1, 2, 3, and 4, of which No. 3 is probably the most useful implement.

The Shovel, Fork, and Rake. The shovel [6] is used for shifting loose soil, clearing trenches, handling manure, and similar purposes. Its blade is broader than that of the spade, and it is usually pointed, so that it can be pushed into piles of loose earth more readily than the spade. A shovel with a long handle is the best, as this obviates the necessity for stooping.



GARDENERS' TOOLS

4. Treaded spade 5. Bulb planter
6. Shovels 7. Trowel 8. French secateur

The garden fork is a most useful though somewhat neglected implement. Much of the work of breaking up ground, which is at present done with the spade, could be done far less laboriously with the fork. A four-pronged fork is the most useful, though some are made with three and some with five prongs. The fork is particularly useful in stirring the surface soil between plants, to aerate it. Short-handled forks are handy implements for taking up small roots, transplanting, or weeding, being, for this purpose, generally handier than the trowel.

The rake is not so much used as formerly, except the wooden variety, which is used for removing dead leaves from lawns, and other similar purposes. There is a variety of rake, however, called the "daisy rake." This has short teeth, very close together. It is used to drag over lawns, to pull off the heads of daisies, dandelions, and other lawn weeds.

Lawn Mowers and Other Tools. Lawn mowers vary a good deal in detail, but most of the best makes are so equal in merit that there is little to choose between them. It is well to consider the area of the grass to be mown in selecting a lawn mower as far as size is concerned. A large lawn mower on a small lawn means expenditure of unnecessary labour, and the same remark applies to the opposite condition—a small mower on a large lawn. The chief thing to be observed is to keep the cutters properly sharpened, as an attempt to mow a lawn with blunt cutters is simply waste of time. The edges of grass which the mower cannot well reach must be cut by means of shears, which are made with both straight and curved handles. In a very large garden it is usual to employ a motor lawn mower.

The pruning knife has been almost superseded by the secateur [8]. This instrument is really a sort of miniature shears, and, in the hands of an inexperienced gardener, is certainly a much better implement than a pruning knife, as it makes a cleaner cut, and there is less danger of cutting away too much with it.

The trowel [7] is an indispensable little implement for transplanting cuttings and small plants. First of all, the hole to receive the plant should be made, and then the trowel should be used to scoop around the root of the plant, and lift it out bodily, when it can be carried on the trowel and placed in the hole prepared for it. A bulb-planter [5] is particularly useful for planting bulbs in lawns.

Other gardeners' tools include the watering-pot, wheelbarrow, saw, and hammer, the uses for which are obvious.

The Little Back Garden. The poor little square patch which is known to the town dweller as the back garden is the most handicapped piece of soil in the world. It is situated so that surrounding walls and sides of houses either cut off air, light, and sun from it altogether, or else admit the blinding glare of the sun's rays to scorch the ground up, while effectually screening any refreshing breezes. Further, the prevalence of smoke chokes up the pores in the stem and leaves of the plants, and prevents them from breathing, while the elaborate systems of drainage with which all towns and cities are replete act indirectly upon the gardens by drawing away the moisture from the subsoil. Without this moisture in hot weather the roots of plants can never be healthy, and success in cultivation becomes more difficult.

Laying Out the Small Garden. These little back gardens are usually square, and where any attempts at gardening are made they generally take the form of a narrow border running all the way round, while the remaining space is devoted to turf, with, perhaps, a circular bed in the centre.

The one point in favour of this plan is its simplicity, but it has the effect of making a garden look hard and formal. A more picturesque way of laying out a small garden is to make the border of an irregular width, curving it in and out as fancy directs, easily and gracefully, though never in such a complicated manner as to appear grotesque.

The centre of the garden can either be laid out simply as grass (the best method where there are children, as it gives them just a few yards to play in), or it may be broken up by arranging for the planting of one or two flowering shrubs, or by the introduction of a bed or beds, as may be desired. A very interesting and easily attained feature of a town garden is a small bed treated as a rock garden, particulars of which are given later.

Trees and Flowers in Town Gardens. Large trees are a mistake in a very small city garden. Although it seems a pity to advocate the cutting down of even one tree, there can be no doubt that their presence in a tiny back garden is a grave menace to the health of the inhabitants of the house, and also militates against success in growing plants, owing to the terrible drain it is upon the nourishing elements in the soil. The same remark applies, to a certain extent, to laurels and privets, which form the lazy man's garden.

The names and habits of many flowers and plants suitable for city culture will be found in later pages, but for general use it may be mentioned that the most useful climbers for hiding walls and fences that face the east or north are the Virginian creeper and Rægner's, or a variegated ivy. Variegated ivies like poor soil; it brings out the variegations better. For sunny situations, purple and white clematises, Veitch's ampelopsis [11], or vine, Canary creeper, Japanese hop, and yellow, winter-flowering jasmine are the best. Of shrubs, the best are the mock orange, aucuba, flowering currant, variegated euonymus, rhododendrons, and Syrian hibiscus.

These may be put in when the laying out of the garden is first begun. If put in in the autumn, a handful of straw laid round the bottom of the stem of the shrub will prevent the frost from getting at the roots.

Window-boxes. Every window, whatever its aspect, can have a box upon its sill in which flowers will grow [11]. Such boxes, with tiles or ornamental fronts, are to be bought, but there is an easy way of making them. Measure the window-sill, and make a box to fit it, about 9 in. deep. Get a piece of clay, and daub it, putty-wise, along all the joints and corners, so as to make it water-tight. To each bottom corner nail a strip or block of wood about an inch deep, so as to prevent the box from standing close on the window-sill. In the middle of the bottom of the box bore three or four small holes, about a couple of inches apart from each other, to allow superfluous moisture to drain away readily.

It is a good plan, in the case of an upstairs window-box, to slide a shallow tin, such as the lid of a biscuit-box, underneath the drain-holes of the window-box, to collect the superfluous moisture. Fill the box to about one-third its depth with bits of broken flower-pots, china, brick, stone, or any similar material, to form drainage, and then fill it up with earth which has been carefully picked over or sifted, to get rid of all big stones, and well mix with silver sand. The window-box need not be a thing of beauty in the summer-time only. When gardening operations begin in the autumn, some dwarf conifers should be put in to keep the boxes bright during the winter, and at the same time bulbs must be planted to keep them gay from March till June.

9. RHODODENDRON BLOOM

One of the most important points in connection with window-box gardening is that the plants should have sufficient water in the winter-time. It is just the season when plants fully exposed in the open air are being soaked by wet and snow, so that if the window-box is in a sheltered position it should be watered, if not as frequently as in the summer-time, at least twice a week.

Trees and Shrubs for the Town. It is impossible to expect a good garden if the trees and shrubs which it contains are either of the wrong sorts or are wrongly planted.

Of the trees most suitable for planting in town gardens, the following is the best selection: Sycamore, common almond, plane, poplar, common elder, horse chestnut, American cherry, ailantus glandulosus, and most of the hollies, which, although of slow growth, will more than repay the care bestowed upon them within a few years after planting. The same remark applies to the euonymuses, of which the variegated sorts are preferable.

A box-hedge is, of course, preferable to one of privet, but, like the holly, the box is of such slow growth that unless a permanent residence is anticipated it is doubtful whether it is wise to plant such a hedge. As an edging in a formal garden, however, there is nothing to equal clipped box.

An excellent, though much neglected, tree for a suburban garden, especially where there is anything in the shape of a lawn, is the black mulberry (*Morus nigra*). Not only does it thrive under the most unfavourable conditions, but yields a generous supply of delicious fruit in the autumn. It is for this reason that it must be grown in grass, as otherwise the fruit—which should not be gathered, but allowed to drop—will be injured when it falls to the ground. The presence of the turf prevents it from getting damaged.

The best evergreen shrub for town planting is undoubtedly the rhododendron [9]. Until lately it was thought to be not quite hardy, but by means of hybridisation many kinds, embracing all colours, are procurable. The old-fashioned ponticum rhododendron is now usually relegated to country-side coverts.

Trees and Shrubs for General Planting. Trees and shrubs which may be used for general purposes in gardens throughout the country embrace some thousands of species. Many of these will thrive only in the sheltered gardens of the South and West of England, and it is useless to attempt to grow them in other districts. They are divided into two classes, one known as deciduous, or summer-leafing, and the other as evergreen. The latter class keeps leaves all the year round, while, during the winter months, the deciduous kinds have nothing but bare stems to show. At the same time, the most brilliant displays of bloom are usually to be found on the summer-leafing shrubs and trees.

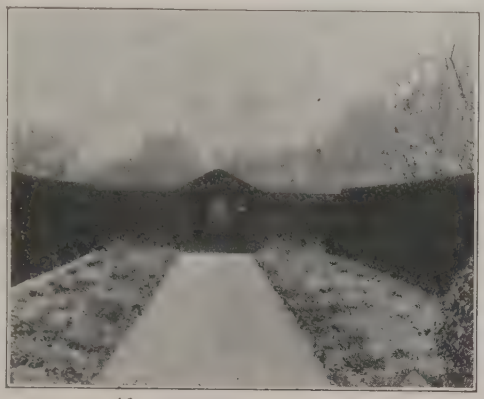
A list of the most useful evergreen trees and shrubs includes the following: Andromeda, arbutus, aucuba, berberis, cerasus, choisya ternata, cistus, cotoneaster, daphne, elæagnus, erica, escallonia, euonymus japonicus, garrya elliptica, hedera, ilex, kalmia, laurus nobilis, olæria haasti, quercus ilex, rhododendron, skimmia, ulex europæus, veronica, vinca major and vinca minor, and yucca gloriosa.

The following are among the best of the summer-leafing sorts: Acer, æsculus, ailantus glandulosus, alnus, amelanchier, amygdalus, aralia spinosa, azalea, berberis, betula, buddlea globosa, calycanthus floridus, carya, catalpa bignonioides, cerasus, corylus avellana, cotoneaster, cratægus, cytisus, daphne mezereum, deutzia, elæagnus augustiofolia, fagus, forsythia, fraxinus, genista, hamamelis, hibiscus, hydrangea, juglans regia, kerria japonica, laburnum, liquidambar, liriodendron tulipifera, magnolia, morus, persica vulgaris, philadelphus, platanus

orientalis, populus, prunus, pyrus, quercus, rhus, ribes, salisburia adiantifolia, salix, sambucus, spiræa, syringa, tamarix gallica, tilia, ulmus, viburnum, and weigelia.

How to Plant Trees. Upon the proper planting of trees at the outset their future welfare depends. It is not sufficient merely to dig a hole in the ground, cram the roots of the young tree or shrub into it, throw back the soil, and make the whole thing firm by stamping upon the base of the stem with an iron-shod boot-heel.

In preparing a hole for the reception of a tree or shrub, it is best to dig it wide and shallow, rather than narrow and deep. The roots should be examined carefully before planting, and any that are broken or injured cut away with the pruning-knife or secateur. The roots should be well spread out in the hole, and the soil gently but firmly pressed in.



10. CLIPPED YEW HEDGES

Should the weather be dry, the young plants should have a liberal dose of water as soon as they are put in the ground. Trees or shrubs that are planted on hillsides, or in other open situations, where they are likely to be exposed to the full force of the wind, should be supported by means of stakes driven firmly into the ground, to which they should be fastened, the stakes being left in for two seasons.

The Time for Planting. Trees and shrubs may be planted with safety at any time between the autumn and early spring—say, from October to March. The bulk of planting is usually done in the autumn, as at this time work is slacker in the majority of gardens than it is after the turn of the year. In town gardens, however, and others in which the soil is of a poor quality, advantage is often to be derived by deferring the planting till the spring. The reason for this is that the roots have the whole of the summer in which to get established before being called upon to undergo the rigours of a winter. A comparatively thin crop of bloom for the first season is the only penalty for this precaution.

Planting should never take place in wet weather, or when the ground is sodden with moisture, as shrubs and trees planted under these conditions are more likely to rot than thrive. It is also useless to attempt planting when the ground is frozen hard, for not only is digging then almost an impossibility, but the soil cannot be properly replaced, and frost will percolate to the roots through the crevices left, and kill the plants. When, of necessity, planting must be done in frosty weather, it is well to cover the surface of the ground round the bases of the stems with a layer of straw, litter, or other mulch, to afford protection from frost.

Transplanting Large Trees. To transplant a large tree, it is first necessary to expose its roots. This is best done by loosening the soil around the base of the tree, preferably with a fork. In judging the distance to which it is necessary to excavate in order to expose the roots of a tree, it should be remembered that, as a general rule, the spread of the roots beneath the surface of the ground is equal in diameter to the stretch of the branches above.

The soil should be carefully cleared away with shovels, care being taken not to injure the roots, which should be lifted up out of harm's way as exposed. When the soil underneath the tree has been well tunnelled, a shallow trolley should be run underneath, and the tree carefully levered on to it, being held in position by props consisting of young larch poles, and secured with ropes. It is well to lift the tree with as large a ball of soil attached as possible, as this not only prevents damage, but helps the tree more quickly to establish itself in its new surroundings. It is important that a transplanted tree should have the same aspect as it did originally. Hence, before moving, it is usual to mark one side of the tree with a dab of whitewash to serve as a guide.

11. THE WINDOW-SILL BEAUTIFUL
(Pelargoniums and ampelopsis)

Making Woods & Shrubberies. The trees most generally employed in the making of woods are the fir, pine, beech, birch, oak, larch, and, to a smaller extent, the elm. This latter tree has fallen into considerable disrepute, especially for belts or avenues overhanging roadway or path, where it is often a considerable source of danger. This is owing to the fact that for some reason, unknown up to the present, heavy branches, apparently sound, have a habit of breaking off suddenly and falling to the ground without warning.

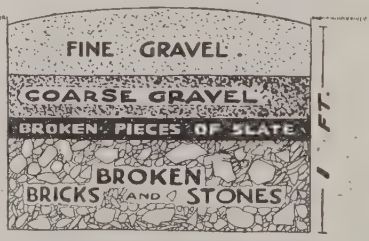
Oak plantations are, in the fulness of time, the most profitable of any, but the reason that so little young oak is laid down at the present day is that it is of very slow growth, and few landowners are prepared to lock up the capital entailed in the establishment and maintenance of oak-woods.

The system which has been found to answer best in making a plantation is to employ nursery-grown plants from two to three years old. These are inexpensive, ranging in price from 5s. per thousand

for the cheaper sorts of firs up to 30s. per thousand for oak and other choicer trees. Opinions differ as to the best distance apart at which to plant these young trees, but a good all-round rule is to allow a space of 5 ft. every way between them. It is usual to "nurse" trees of slower growth, such as oak, by planting a quick-growing timber, such as larch, between them. By the time the oak is sturdy enough to take care of itself, the larch may be thinned out and cut down, if it is not desired to retain it.

Some of the tenderer growing firs are often "nursed" in a similar manner, but there is a simpler way in dealing with this variety of tree. This is to sow the ground, when planting the young firs, with seed of the common gorse, which, being a very rampant grower, speedily affords all the protection needed. Care must be taken not to let it go too far, however, or the gorse may choke a large number of the young conifers. Many firs have a tendency to develop what are called side breaks. These are shoots which appear near the top of the tree, so that instead of tapering away gracefully to a point, as it should do, the centre stem breaks away in three or four directions, not only destroying its symmetry, but greatly lessening its commercial value. These side breaks should be cut off in the early stages of growth.

Where not to Plant Trees. Much care must be exercised as to the position in which young trees are planted. The gardener who fails to look far enough ahead is apt to place them where, although they are very pretty and effective for the time being, they will be the source of great trouble, say, fifty years hence. Trees should never be planted quite close to a house. First of all there is a danger that the roots may spread sufficiently to injure the foundations of the building; secondly, if the house be a low one, there is risk of damage from the dripping of the rain upon the structure as it falls from the leaves and branches; and, thirdly, the presence of big trees near a house interrupts the free circulation of air, and consequently makes the place damp and unhealthy.



12. MAKING A GRAVEL PATH

It is not wise, either, to plant a tree quite close to the edge of a path, for, as it grows older, it will be found necessary either to alter the course of the path or remove the tree.

Making Hedges. A living hedge is always better than a dead wall, and wherever they can be used in gardens in the place of dividing lines of wood or brick, hedges should certainly be planted. Unfortunately, practically all the trees which go to form good hedges are of slow growth, and take a good many years to form a substantial barrier. The quickest growing of all hedge plants is the privet, and this is probably why it is seen so much in every little suburban front garden. At its best it forms but a straggly barrier, and where, owing to circumstances, it cannot be dispensed with, its ugliness may be redeemed by employing one of the variegated sorts. Plants about a foot in height should be used, and they should be put in in the autumn or spring, at a distance of about 9 in. apart, or closer, to form a thick hedge.

The best hedge of all is the holly hedge, but this is one of the slowest to attain respectable dimensions. Plants 2 ft. in height are the best to begin with, planted from 1 ft. to 2 ft. apart, according to their size. They should not be trimmed for at least two years after planting. An old holly hedge forms a barrier that nothing can get through, especially if it be clipped regularly.

The ordinary hawthorn hedge requires practically the same treatment as the privet, though, if it is not cut back within a year or two after planting, it is apt to get very "leggy," the lower part being nothing but a collection of stems.

A yew hedge is probably, next to the holly, the densest and most compact, provided it is clipped regularly in the early spring, before the young growth commences [10]. It should, however, only be used inside a garden, and not to form a boundary by a road or field, or any other place where horses or cattle will be likely to get at it, on account of its poisonous nature.

A Hedge of Sweetbriar. One of the most charming garden hedges, though not a boundary hedge, may be formed with sweetbriar. Though this is very little used generally, it makes the most fragrant of all hedges, and deserves to be much more widely known than it is for this purpose. It can be planted at any time when the roses are being planted, and can always be clipped into a neat, compact shape. This is quite hardy and simple for town use, and is full of perfume during the summer months, in direct contrast to the privet, which, at this time of the year, bears evil-smelling flowers of a dirty white colour.

Near the seaside the euonymus makes a splendid hedge. Particularly is this the case on the South Coast, most of the favourite Sussex watering-places having excellent examples of what can be done with this plant for hedge-making. The tamarisk and the sea buckthorn are also useful in these situations.

During the early years of a hedge's life, it is necessary to watch the young plants very closely, and remove all dying or weakly specimens, otherwise, when the hedge attains maturity, gaps where weakly plants have been will be disclosed.

In clipping hedges, no matter of what nature, they should be cut wedge-shaped, to a certain extent, the narrowest part being at the top. In this way the lower portions are not overshadowed, and thick growth at the base is encouraged.

Walks and Lawns. The making of walks and lawns, and the preparation of formal beds for the latter, are branches of gardening which have to be carried on in such near relation to each other that they should be studied simultaneously.

Most gardens have too many walks. In public parks, certainly, a large number of paths is necessary, because it is only by providing this sort of accommodation for them that a crowd of sightseers can be kept within bounds. No such precaution is necessary, however, in a private garden, where the majority of the walks should be grass ones, prepared and looked after in the manner recommended for lawns. It is impossible to lay down a hard and fast rule as to where a gravel path should be put, as conditions differ in practically every garden of decent size. The carriage drive, of course, must be gravel, so must the main walk to the kitchen garden, the one to the glasshouses, and others which are being tramped over every

minute of the day. An economy, both of time and labour, is effected by making most of the others grass walks.

Unless the exigencies of space compel, it is better never to make a gravel walk a perfectly straight one. Such a path, running hard and uncompromisingly out in the perspective, is rarely a pleasing sight, even if fringed by the choicest flowers. At the same time it is absurd to make a path wriggle all over a garden for the mere sake of doing so.

Nowhere in the world are such lovely lawns to be found as in our own gardens, and few things are more refreshing to the eye, or more beautiful, than an expanse of smooth, unbroken turf. This fact should be borne in mind when laying out a garden, and care should be taken to keep all beds near the edge of a lawn, and not to go dotting them at regular intervals all over the turf just for the sake of symmetry. The aspect of such a garden is sure to be hard and unnatural.

How to Make Walks. The first step in the making of a walk or path is to map out exactly where it is to go. In the case of a large garden, a plan must be prepared on paper first, otherwise confusion will invariably result; but with a small garden this is not necessary. Then the course of the path must be traced out on the ground by means of cords, to which, at intervals, small pegs are attached. These strings and cords are one of the gardener's most important tools in the early work on the ground, as they serve to outline every bed and border, and determine the width and direction of every path.

When these points are satisfactorily settled, the soil, to the depth of about 1 ft., should be dug out all along the course of the proposed path, and carted away. Needless to say, it will be much appreciated elsewhere. At the bottom of the trench thus made a layer of broken bricks and large stones should be distributed in as level a fashion as possible, to the depth of 6 in. or 7 in., for the purpose of drainage. They should be well crammed down, and covered with 2 in. or 3 in. of coarse gravel, which must be well rolled in. Upon the top of this the final layer of fine gravel rests, to the depth of 2 in. or 3 in. In building up the path the surface should be made a little higher at the middle than at the sides [12].

If available, a layer of pieces of broken slate, about 2 in. in thickness, should be placed between the broken brick layer and that of coarse gravel, as worms cannot penetrate this material, and unsightly worm-casts are prevented. Much rolling is necessary when a path is first made, as otherwise the top layer will never become hard and firm.

When once a walk or path is made, there is always

13. WATERSIDE PLANTS, KEW GARDENS

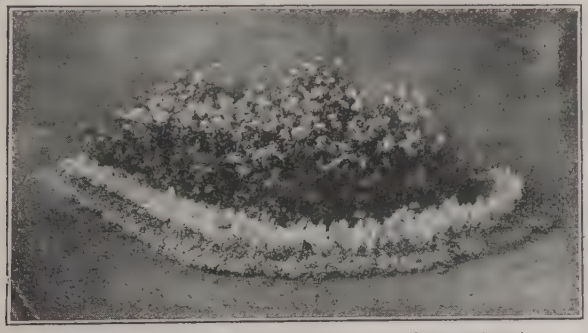
the task of keeping it free from weeds to be considered. By far the most efficacious way is, of course, to pull up the weeds by the roots as fast as they make their appearance. There are many chemical weed-killers on the market, but they require very careful handling, as not only do they kill weeds, but everything else with which they come in contact. A dressing of salt is a pretty effective weed-killer, and an application of boiling water serves a similar purpose.

A stone path is a good path if properly constructed, and is always practically dry. In constructing such a walk, proceed as indicated for gravel walks, until the layer of coarse gravel is laid and rolled. Upon this should be laid just an inch or so of soil, and in this, embedded roughly, shaped pieces of flat sandstone, in the form of an irregular mosaic. Old paving stones, such as may be procured from any contractor's yard, and broken up with a sledge hammer into pieces of any size from 6 in. to 2 ft. across, are excellent material for the purpose. As these are embedded, a little soil should be pressed into the chinks between each piece, and in these chinks stonecrops and mosses may be planted. These will quickly establish themselves, and form a very pleasant walk in the course of a season or so. Such stone walks are comparatively rarely met with, and the present vogue of the rock garden which uses up a large quantity of broken sandstone makes their establishment somewhat expensive. They are very artistic and effective.

The Making of a Lawn. There are two ways of making a lawn—by turfing and by seed. In places where, in forming the garden, good turf has been cut off and stored from parts of the ground when levelling is going on, it may well be replaced; but where an entirely new lawn has to be made it is better to employ grass seed than to purchase turf and lay it.

Before sowing, an operation which is best carried out in the springtime, the ground should be well dug over with a spade, all lumps being broken up with a garden fork, and afterwards gone over with a rake, to ensure that the surface soil is nice and fine, and, moreover, free from stones. Then go over it with a light roller, being careful, especially in the case of a tennis lawn, to see that it is quite level.

As soon as the surface is nice and smooth, it is ready to receive the seed. The regulation quantity of seed, as recommended by all the leading authorities, is 1 lb. of seed to every 16 sq. yd. In other words, a bushel of grass seed will sow



14. A MIXED BED (Mostly *Lilium speciosum rubrum*)

an area of 400 sq. yd. Two apparently trivial but really important points must be observed when sowing a lawn. There must be no wind, and the sower must not wear high-heeled boots. Grass seed is very light, and even a moderate breeze would blow it into uneven patches as it leaves the sower's hand, while high heels would dig into the ground, in its unsettled state, and disturb the level. Careful gardeners wear flat pieces of wood, with straps to fasten over the boots, when sowing.

When the seed is sown it should be covered by just the slightest covering of loam or sand, and rolled lightly. If the soil be a heavy clay, the covering of sand will be the best, while if the soil is in itself a light one, it will benefit more by the sprinkling of loam. This must in turn be rolled, but lightly, otherwise the delicate little blades of grass might find difficulty in forcing their way to the surface. Where there is any danger of the seed being attacked by birds, black threads should be stretched at intervals across the ground, 2 in. or 3 in. above the surface.

The new lawn should not be rolled or swept until the grass is 2 in. or more in height, when it may be rolled lightly and swept gently. A lawn mower should never be used to a new lawn, as it is apt to tear the tender young grass up by the roots. The scythe is the proper implement to employ for this purpose. Scythe mowing should be carried out early in the morning, when the dew is on the grass, as the scythe works best at these times. The mowing machine, which may be used when the summer comes and the grass has got well established, works best when the ground is dry, and may therefore be employed at midday. To ensure a good velvety turf, a lawn should be well mowed and rolled at least once a week. Daisies, dandelions, and other weeds should be rooted up without mercy by the instrument known as a daisy fork.

15. A PINK-FLOWERING WATER-LILY (*Nymphæa rosea*)

Carpet-beds on Lawns. A carpet-bed is a bed formal in outline, and also in the nature of its contents, which consist of dwarf plants of a similar height, arranged in a set pattern, sometimes to form a word or motto, or else according to a geometrical plan, so that they resemble a part of a pattern or a carpet. Carpet-beds are not by any means the only sort of beds that can be made on lawns [14]; but as lawns are the only place for them, and their preparation is really part of the garden design, it is best to deal with them here.

Many gardeners maintain that to arrange plants in such a formal way is an outrage upon Nature, and ought to be tabooed; while, on the other hand, there are many gardens in the kingdom where carpet-bedding is carried to excess, and the only effect is a hard and ugly one.

The best way is to strike an intermediate line, and have a little carpet-bedding, if it be desired, near the house, whence the bedding can gradually get less and less formal, until it merges into the wild garden.

Before making a carpet-bed, the design should be drawn out on paper, and marked with the names of the plants it is proposed to use in each section to give the varying colours. If the bed is to be circular, it is usual to peg out a square on the site, and then cross it with two diagonal strings. Where these strings meet is the centre of the bed. Place a peg there, with a string attached, and, just at the point where the string touches the side of the square tie an old knife, steel point, edging tool, or anything that will cut the turf. Then, by dragging this round the ground, a perfectly circular cut will be made.

Plants for Carpet-bedding. The soil for a carpet-bed should be broken up fine, or sifted, for preference, and a little sand mixed with it, unless the soil is already sandy itself. Before, however, the work can be proceeded with any further it is necessary to prepare the plants which are to fill the carpet beds. These are a class by themselves, and their culture is of the simplest. The pyrethrums, which give gold, pale green, grey, and yellow tints, are grown from seed, which must be sown in a greenhouse, with heat, in early spring, in boxes of sandy soil, and will be ready for putting out in the bed in May, which is quite soon enough, in order to escape the possibility of a touch of late frost. Red and blue lobelia are treated in a similar manner.

Alternantheras are another important family for carpet beds, and their colours range from yellow to red, but cuttings of these must be purchased in the first instance as seed is not readily procurable. These cuttings must be put into sandy soil, and rooted on a hotbed. A hotbed is made in a frame, or frames, in the garden, and consists of a layer of about 18 in. of manure, covered with a good layer of soil. The decomposition of the manure induces heat, and this heat causes the cuttings to take root and thrive. As the spring progresses, the glass top of the frame should be raised during the day to allow the young plants to gradually harden off. Other prominent carpet-bedding plants are iresines, antennarias, stonecrops, and Herniaria glabra. In preparing plans for carpet beds, particular attention should be given to the harmonious blending of the colours of the plants.

When the plants are ready for putting out, the pattern of the bed must be carefully mapped out on its surface in silver sand, and the young plants put in, about 2 in. apart, with great accuracy, commencing at the centre and radiating outwards.

A carpet bed, carefully prepared, will last on into the autumn until the early frosts spoil it. It should then be cleared, and, in order to avoid ugly brown beds during winter, they should be planted with dwarf evergreens and bulbs of snowdrop, crocus, and early-flowering daffodils, the culture of which will be dealt with elsewhere.

The Rock Garden. Rock gardens, as at present constructed, are, generally speaking, capable of a great deal of improvement, and in preparing one its true purpose should not be lost sight of. This purpose is, in the main, to enable the choicest Alpine and other mountainous plants to be grown in this country under as natural conditions as possible. Therefore the piling up of masses of rock and stone with no thought for the needs of the plants that are to adorn them is not at all likely to produce satisfactory results. It is most important to remember that the plants, and not the rocks, represent the most striking part

of the scheme, and the introduction of vases, statues, and other eccentricities into a rock garden is not desirable.

The spring is the best time of the year in which to begin making a rock garden, and a sunny position in the garden is the best spot at which to construct it. It may be of any size, but should be irregular in shape, though there is no need to go out of the way to make it curious in this respect. If the soil is not good and deep at the spot where it is proposed to construct the rock garden, the ground must be dug out to the depth of 18 in. or more, and a good mixture of peat, loam, and sand put in its place. This bed of soil should be raised well above the level of the surrounding ground, or a picturesque effect will not be obtained. The so-called rocks may be pieces of any kind of stone which is common to the district. In fact, in towns, many effective little rock-beds can be built up by employing pieces of ordinary sandstone pavement, broken up into irregular shapes. Sufficient for the purpose can generally be procured at a nominal price at any builder's yard.

The whole secret of successful rock gardening is this: Plants suitable for growing under these conditions require full exposure to the sun, though at the same time they must have plenty of moisture at the roots. Hence the real use of the rocks is to act as a shield and prevent the evaporation of the moisture so essential for the well-being of the plants.

There are some shade-loving rock plants, but they are comparatively few in number compared with the others. It is impossible to lay down any hard and fast rule as to how pieces of rock should be arranged in every garden—so much depends upon position and surroundings in each instance. Individual taste must be brought to bear upon the matter, taking care to avoid all trace of formality and "building" [16]. Rock gardens should never be made near trees, as their shade destroys the very object with which it was constructed.

When first constructing a rock garden it is best to put a few pieces of rock in the most prominent positions, and then insert the plants, gradually embedding the minor pieces of rock in the soil as the planting goes on. In this way not only is a more natural aspect assured, but the plants are more securely rooted than they would be if the rocks were arranged methodically at first, and the plants tucked in between the crevices afterwards. One or more members of the following families go far to make up a representative collection for the sunny part of the rock garden: Alpine harebell, orchis, Alpine anemone, stonecrop, allium, androsace, antennaria, arnebia, armeria, chionodoxa, colchicum, daphne, Alpine pink, sea-holly, dog's-tooth violet, geum, iris, leucojum, lithospermum, muscari, pentstemon, Jacob's-ladder, potentilla, primula, saxifraga, sempervivum, sternberga, trillium, trollius, foamflower, and viola. Those which thrive best in shady situations are the lady's slipper (hardy cyrpripedium), gentian, ranunculus, epimedium, hepatica, and iberis.

16. A WELL-MADE ROCK GARDEN

Water Gardens. It is quite possible to construct water gardens in places of modest dimensions; in fact, there are many instances in which water lilies have been successfully grown through no more ambitious medium than a half-barrel sunk in the ground. The orthodox method of making a pool in a country garden is to dam a stream at some convenient spot and form a pond of the overflow.

Where there is no stream at hand, the water must be brought to the spot by pipes, if ambitious water gardening is to be attempted. First of all the piece of ground which it is proposed to transform into a water garden should be dug out to the depth of 3 ft. or 4 ft., and the soil carted away. The edge of the hollow thus made should be purposely left irregular in shape, as, if it is cut square or circular in form, the effect is formal and unpleasant. A layer of clay about 1 ft. in thickness should then be spread over the bottom of the basin, and thoroughly beaten into the ground. This operation of beating is most important, as it is to render the basin watertight, and if carelessly done the water will leak away. On top of the clay a layer of good loam from 6 in. to 9 in. in thickness should be spread, and the water may be let in.

Water Lilies in the Small Garden. Even where the only water available is the half-barrel just alluded to, it should be sunk well below the level of the ground, and the formal edge broken up with a few groups of moisture-loving plants. The best form of barrel to employ is a petroleum or beer cask. It should be sawn in two, and charred on the inside so as to remove all traces of oil or alcohol. It should then be pitched on the outside, after which it is ready to be plunged into the ground. At the bottom of the barrel place a layer of good stiff clay, and on top of this a few inches of a compost of two-thirds good fibrous loam and one-third old, well-decayed leaf soil. This should leave ample room for about 1 ft. of water, which

can be poured gently in after the water lilies have been planted.

Water lilies can be grown quite easily in this way even in suburban gardens, as they will thrive better in a stagnant pool than in running water.

Planting water lilies in the water garden is merely a question of getting an openwork basket, filling it with soil, and inserting the tuber. A stone should be tied to the basket to prevent it being washed away, if the water has a current. Water lilies thrive best when fully exposed to the sun, and the best time for planting is during the months of April, May, or June. The following nymphæ are the best six to plant: Alba, Rosea [15], Froebellii, Laydekeri, Odorata, and Robinsoni. Other flowers which should be planted in the water itself are nuphar (often mistaken for a water lily), the Cape pond-flower, buckbean, arrowhead, reed mace, arum lily, bullrush, and the water forget-me-not.

As the banks of a water garden are sure to be damp and marshy, they should be liberally planted with moisture-loving things in the springtime [13]. Among the best of such plants are the Japanese iris, marsh marigolds, globe flowers, several varieties of the hardy bamboos, day lilies, American swamp lily, royal fern, and several of the arundo, or reed family.

The Wall Garden. The wall garden is almost a thing of the past, except in old-established places, notably those in the West of England. This is probably due to the fact that brick walls and wooden fences have practically superseded stone as boundary lines.

A good wall garden is, however, always a charming sight, and may, for the sake of illustration, be called a vertical rock garden. The whole system of wall gardening consists in planting suitable subjects between the chinks and on the top of stone walls, taking care that such chinks have sufficient soil to enable the plants to live. The best of all these plants is, naturally, the wallflower itself (*Cheiranthus cheiri*), which is sometimes found self-sown on the sides of disused quarries, chalk pits, and in other similar situations. It seems to thrive on practically nothing, growing almost on the bare rock itself. The majority of wall plants are rock-garden plants as well, though their number is necessarily limited, as most rock plants are deep-rooting subjects. Varieties of the following are among the most suitable: Alyssum, arabis, erodium, gypsophila, linum, polypodium, saxifraga, sedum, and sempervivum.

Climbing Plants. One of the principal features which make or mar a garden are climbers. This is particularly noticeable in gardens of modern formation, which are usually those attached to ugly houses. So few modern-built houses are handsome in appearance that it is a good thing to clothe them, as far as possible, with climbing flowers and plants. It is not only against the walls of houses that the climbing plants are both beautiful and desirable, but out in the garden itself, where summer-houses, arbours, covered walks (which are known as pergolas), walls, fences, old tree stumps, and many unsightly objects may be improved by their use. In many cases, indeed, climbing plants may be allowed to grow over living hedges and up tree trunks, though in this last capacity they should be employed in moderation; if used to excess, the result often gives the impression of careless gardening. The climbing plants most sought after are, naturally, those varieties of the rose which have this habit. They will thrive in almost any aspect, though, naturally, such good results cannot be expected on a wall facing north as in more sheltered situations. In a loamy soil, which is about 2 ft. deep, however, they would do well, even in many town gardens. It is a mistake to prune climbing roses too freely; nor should they be nailed against the wall at every few inches, as if they were undergoing a species of crucifixion, but only given such support as is absolutely necessary, so that they can make their way upwards as naturally and gracefully as possible. This remark applies to practically all climbing plants. The best of the climbing roses are: Reds—Crimson Rambler, Cheshunt Hybrid, and Waltham Climber. Yellows—Blairii No. 2, Gloire de Dijon, Bouquet d'Or. White—Aimée Vibert and Niphetos. Pink—Climbing La France and Pink Dorothy Perkins. Apricot—William Allen Richardson, Rêve d'Or, Madame Berard.

Clematis and Creepers. Next in importance to the rose as a climbing plant is the clematis. Most of the varieties are grafted on wild clematis. The most useful hybrid for general purposes is Clematis Jackmani, the large purple flowers of which are so often to be seen in town gardens. It has a variety—Alba—whose flowers are equal in size and number, and white in colour. The clematis flourishes well in a light soil, and flowers freely from May to July.

Other spring and summer flowering climbers include the wistaria, white jasmine, and the honeysuckles, while seed of the common climbing nasturtium and canary creeper, sown at the bottom of an arch or arbour during the month of April, will cover it in a month or two. Being annuals, sowings of such plants must be renewed every year.

For exposed situations there is, of course, nothing to equal the common ivy, or one of the variegated sorts. This has the advantage of being evergreen, and is consequently in evidence all the year round. The Virginian creeper is noteworthy for its beauty in autumn; but after the leaves fall it presents a very untidy appearance. A much neater climber of this class is Ampelopsis Veitchi.

Winter Flowering Climbers. There are three climbers which are of inestimable value, as they flower in the winter time. Two of these are admirably adapted for town gardens. The best is the yellow-flowered jasmine, which, though its stems are bare at the time, is covered during the most unfavourable months of the year with a shower of bright, yellow blossoms of diminutive size, which make a brilliant contrast with the dark-brown stems of the plants and the brick walls.

The second perfectly hardy winter climber is the pyracantha, which it is hardly accurate to describe as "flowering," as it is its bright orange-red berries and rich dark evergreen foliage which render it valuable during the dark days. It thrives with equal vigour in any sort of soil.

In favoured situations the winter-sweet (*Chimonanthus fragrans*) may be grown on a south wall. Like the jasmine, its flowers are borne on bare stems. It is particularly sweetly scented, and if the flowering shoots are cut and floated in a shallow vessel of water, they will diffuse their fragrance through a dwelling-room for many days. No harm is done by treating the shoots in this way, as in the ordinary course of events they would be pruned after flowering. Winter-sweet, however, is not suitable for town gardens.

H. H. HAVART

History, Nomenclature, and Classification of Artificial Dyestuffs, with their Properties, and Modern Processes of Dyeing.

ARTIFICIAL DYES

Artificial Dyestuffs. Although the dyer's art is prehistoric, he has been dependent until little more than half a century ago entirely upon natural colouring matters, and of these comparatively few only of the immense variety provided by the animal and vegetable realms have been used in dyeing. The reason is that the natural dye in some cases depends for its existence on the life of the plant or animal whose vital processes have produced it, in others that it resists every attempt to extract it, or that when extracted it is too fugitive and unstable on textile fabrics to be of any service. Although some of the usable natural dyestuffs are of an excellence hardly yet surpassed in some directions by artificial products, as a rule these latter are much simpler in use, a matter of first importance to the dyer. Hence, short as the life of the artificial dyestuffs has been, they have driven the majority of their predecessors from the field which they have occupied alone for so many centuries, or at least have greatly restricted the scope of their utility. Being definite substances, and therefore always possessing the same properties, they are simpler and more certain in their application than the natural dyes.

Although of such recent origin, the manufacture of artificial dyes has developed at a rate probably unparalleled in the history of industry. It would probably be a safe assertion to say that the number of patents taken out for coal-tar products exceeds that obtained for any other class of invention.

History of Artificial Dyestuffs. In April, 1856, William Henry Perkin, who died in 1907, made a substantive dye for silk known as Perkin's mauve. He was trying to synthesise quinine by oxidising aromatic bases. He found that the bluish precipitate produced by the interaction of aniline and bichromate yielded a splendid violet solution with alcohol, and the dye was obtained by evaporating the tincture. The result was British Patent 1984 of 1856, taken out after consultation with Pullar, the Perth dyer. In partnership with his father and brother, he erected a factory at Greenford Green in 1857, and began to put Perkin's mauve upon the market in the following year. Aniline was thus the first coal-tar product which yielded a commercially useful dye.

Perkin's dye was first sold in this country by the name of Tyrian purple, but on the Continent it was called Perkin's violet or mauveine. It was largely used for silk sunshades, and was until lately used for paper for postage stamps.

Perkin's success set chemists at work on coal-tar. The next discovery was magenta, obtained by Verguin in 1859, by acting on aniline with stannic chloride, and in the same year the second artificial dye factory was erected by Geigy & Co., at Basle. The French patent law of 1844 prevented much being done in France. Hence, when Durand and Gerbert Keller introduced the use of mercury salts in the preparation of magenta, they went to Basle.

In 1860 magenta was £30 a pound, and this and mauve were the only artificial dyes at that time made from coal-tar. In that year, however, azuline, the first coal-tar blue, was discovered, and the method of preparing magenta by oxidising a mixture of aniline and toluidine with arsenic acid was invented by Medlock, and brought the dye into commercial use. Two important events mark the 'sixties—the perfection of aniline black by Lightfoot in 1863, and the synthesis of alizarin, one of the colouring matters of madder, by Graebe and Liebermann, and also by Perkin, in 1868, both epoch-making achievements. Graebe and Liebermann thus effected the first synthesis of a natural dyestuff. Their process was not, however, a commercial one, but Caro and Perkin soon introduced the sulphonating process still employed. A large number of new dyes was soon added to the small list then existing, and the new industry was fairly launched.

Synthetic Dyes. It is impossible to devote sufficient space to give more than a vague idea of the methods of colour manufacture [see page 5198]. The methods whereby synthetic dyes are prepared from the raw material or from the intermediate products which have to be made from the former as a preliminary step may be classed under two categories—substitution methods and coupling methods. It is by substitution, too, that the intermediate products are prepared. Substitution means replacement of part of the molecule of the initial product by a part of the molecule of some other substance. Coupling means simply the combination of two molecules which, although able to exist by themselves, have nevertheless certain "unsaturated" affinities which will enable them to unite into a single substance.

Nomenclature of Dyestuffs. An aniline was the first coal-tar dye discovered, and since the days of Perkin's mauve the British public have spoken of all artificial dyes as anilines. The alizarines, however, are not anilines, and the discovery of this large group was very early in the history of coal-tar dyes. The first sulphur colour was not even a coal-tar dye, and petroleum residues are used in some places, Russia, for instance, in place of coal-tar as a raw material. The correct term, therefore, unless we are speaking specifically of an aniline, is "artificial organic colouring matter," which completely fills the field.

Artificial dyes, to content ourselves with a shorter term, with some exceptions, are definite chemical substances, but the makers, for good and sufficient reasons, put them on the market under a commercial or "trivial" name. It is obvious that it is easier for the dyer to ask for Bismarck brown than for hydrochloride of benzene-diazo-phenylene-diamine, and this is simplicity itself as compared with the chemical names of some of the dyestuffs. The only inconvenience is that the same dyestuff is often on the market under a variety of names. That already instanced was called Bismarck brown for obvious complimentary reasons by its German discoverer, Manchester brown by the Manchester firm who improved the method of manufacture, English brown possibly by way of protest, phenylene brown from its composition, leather brown when it was found to be suitable for that material, and cinnamon brown because of the rich, reddish brown shade it gives.

As a rule, the commercial name suggests the colour produced by the dyestuff (diamond yellow), and in some cases the particular tone or tint (turquoise blue). It frequently gives an indication of the chemical origin of the dyestuff (resorcin brown), or claims special properties of resistance (milling yellow), or, as in the case of night blue, of remaining unchanged in an artificial light. Very frequently the recommended use is indicated, as, for instance, wool scarlet, union black, cotton blue; or the way in which it is to be used, as, for instance, chrome green, spirit blue.

Names indicating Colour. The names indicating colour have been taken from all sources. From flowers we get primuline, rhodamine, and rosophenin, from the Greek and Latin respectively for a rose, mimosa, and others. A number of dyes commence with a Greek or Latin name meaning or suggesting a colour: chrysamine, chrysoidine, auramine (golden), citronine (lemon), cyanol, cyanine (blue), eosine, eosamine (*eos*, the blush of dawn), flavine (yellow), irisamine (*Iris*, the rainbow), nigrosine (black), pyramine (fiery), chlorine (yellow), and others. Uranine comes from uranium, whose compounds show fluorescence, now said to be due to radium, and fluorescent blue and fluoresceine convey the same idea of a changing colour effect. Some names are frankly popular and topical, as, for instance, Magdala red, Congo red, Guinea green; and others, as in the case of Perkin's mauve and Meldola blue, commemorate the discoverer.

The letters following the names are not meaningless; as a rule they indicate the particular tint. Thus brilliant Congo R gives a frank red, while brilliant Congo G (*gelb*, German, yellow) has a yellowish tinge. The degree is shown, a sin the case of benzopurpurines, which are sent out in four "brands," ranging from B, a slightly bluish red, through 4B and 6B to 10B, a very bluish red.

Classification. Classification is essential in the consideration of any subject, but with the artificial dyes, as with all other great groups, the sub-classification is difficult, and, on whatever principle we proceed, is only a makeshift at the best, though a very necessary one. In classifying the artificial dyes, we may consider their chemical composition, their method of application, or their effects upon different textiles. It seems best to arrange them with some reference to all these points, and we propose to make six main classes as follows: (*a*) Direct Cotton Colours; (*b*) Acid Colours; (*c*) Basic Colours; (*d*) Ordinary Mordant Colours; (*e*) Acid Mordant Colours; (*f*) Insoluble Colours. It must, however, be noted that there are dyes which belong to two or even three of these classes.

Direct Cotton Dyes. These dyes are so called because they dye vegetable fibre without the assistance of a mordant. It is evident, therefore, that they dye other textiles direct, for cotton has less affinity for dyestuffs than wool or silk. With the exclusion of the sulphur dyes—which are not classed as direct dyes, and in this course it seems best to take with the insoluble dyes—the first direct cotton dye discovered was Congo red in 1884.

The direct cotton dyes are compounds of various colour acids with alkalies, and are, therefore, all decomposed by acids. Unless, then, the colour acid set free happens to have the same colour as the original dye, the shade produced is not fast to acids. Most of the group are decomposed by hard water with precipitation of a lake, and therefore the water for the dye-bath should be softened for use.

The direct cotton dyes used directly are not very fast, as a rule, especially on cotton and linen, but their resistance to external agencies can be greatly increased by treating the goods in various ways after dyeing. Sulphate of copper and chromium compounds are largely used for this purpose, and many of the direct cotton dyes can be fixed by diazotising.

The direct cotton colours are not much in vogue for wool, which can be more cheaply coloured by means of acid dyes, but for mixtures of wool and cotton they are used in a neutral bath.

Accelerating and Retarding Agents. Every member of the class requires an assistant in the dye-bath, either to accelerate or retard the going on of the dye. For the former purpose Glauber's salt or common salt is employed; for the latter, carbonate of soda or even caustic soda or soap. It is very common to use both a retardant and an accelerant. Thus in many cases, the first part of the dyeing is done in the presence of carbonate of soda, and Glauber's salt is added to the bath later. Soap is often used with Glauber's salt or common salt for mode shades.

The direct cotton colours are dyed on wool at the boiling point, and in a neutral or alkaline bath, and with the same assistants as cotton. Some of them can be dyed in a bath made slightly acid with acetic acid, but even with these a neutral bath is preferable. However, the property of dyeing in an acid bath is made use of in dyeing mixtures of wool and cotton. The use of acids tends to make wool take a redder shade than cotton does under the same circumstances, and this prevents level dyeing of mixtures.

In the case of silk, the dye-bath is best made with soap broken with acetic acid. An after-treatment exactly as for cotton is required if great fastness is a desideratum, although the direct cotton colours are faster on either wool or silk than they are on cotton.

The direct cotton colours can be combined freely in the same bath, so that any possible variety of shade is easily procured. Whenever practicable, however, those dyes should be selected for mixing which require the same assistant. If this cannot be done, the assistant must be chosen with regard to the dye which is added in largest quantity. Baths of the direct cotton dyes very rarely exhaust, and can be kept standing, reinforcing them with more dye and Glauber's salt when each fresh batch of goods is put in. The shorter the bath—that is, the smaller the excess of weight of the dye-bath over that of the goods—the better the exhaustion. Large amounts of assistants also favour exhaustion, which, of course, depends on the affinity of the fabric for the dye, so that, other things being equal, the bath will exhaust better with wool or silk than with cotton. A strong bath has the advantage, in the use of the direct cotton dyes, that it gives deeper and fuller shades. Hence it should not be diluted by heating with direct steam. The heat should be applied with a closed coil. It is a good plan to allow the goods to cool for some time before lifting them. This conduces to uniformity of shade, which is to some extent imperilled by the use of strong and short baths. An average length of bath is from 200 to 250 gallons per 100 lb. of goods.

An important property of the direct cotton colours is that they act as mordants to the basic dyes, so that useful colours can be got by topping; that is, by dyeing first in a bath with direct dyes, and then "topping"—*i.e.*, re-dyeing—with a basic

colour. The lakes formed, however, are decomposed at about 160° F., so that the topping bath must be below that temperature. The diamines brought out by Cassella in 1889 belong partly to this class. Some are diazotisable colours.

As regards the after-treatment, bichromate of soda or sulphate of copper, already alluded to in this connection, are the usual agents, but diazotising is often resorted to. In this process the goods, after dyeing and rinsing, pass through a bath containing 1½ per cent. to 2½ per cent. of sodium nitrite and 5 per cent. to 8 per cent. of hydrochloric acid. This bath must be kept cold. It was at first considered necessary to use ice, hence these dye-stuffs were known as "ice" colours. Development follows with one of the numerous developers upon the market. Beta-naphthol—1 per cent. dissolved in caustic soda—is perhaps the most commonly used developer. This diazotising process affords great scope for shading and dyeing to pattern, for mixtures of azotisable and non-azotisable dyes, and a mixture of developers, can be used on the principle that the final colour depends partly upon the developer.

Most of the garment cloth now on the market is a union fabric—that is, a mixture of wool and cotton. This is dyed in the piece with direct cotton colours, the dye-bath being made simply with colour and Glauber's salt. Some direct dyes do not go equally on the two fibres. Others require management of the bath, the wool taking most colour at the boil, whereas the cotton continues to take it in the cooling bath. The household dyes sold in packets are selected direct cotton colours.

Basic Dyes. These are the oldest coal-tar dyes known, inasmuch as Perkin's mauve is one of them. Safranine was discovered in 1863, and Bismarck brown—the first azo dye—in 1864. In constitution the basic dyes consist of salts of colour bases. They are direct dyes for woollens and silks, and adjective dyes for cotton. Most of them are soluble in water, and all in spirit. A few of them, such as auramine, are decomposed by hot water, and they should not be used with hard water, which precipitates and wastes them, as it does the direct cotton colours. They are brilliant colours, but not remarkably fast. On cotton they are usually dyed on a tannin and tartar emetic mordant. Iron salts are sometimes substituted for the antimony salt, or Turkey-red oil or soap mixed with acetate of alumina. If the tannin process is adopted, a very short tannin bath at about 170° F., and containing about 5 per cent. of tannin, is used, although some require more tannin for several hours. The goods then pass direct into a solution of from ½ per cent. to 2½ per cent. of tartar emetic, according to shade. This bath is kept standing, and is reinforced as may be necessary. If difficulty is found in getting level shades, as occasionally happens, the goods should be mordanted after, instead of before, dyeing. In dyeing dark shades it is a good plan to use decoctions of natural tannins, such as sumach, as the natural colouring matter present in the solution saves some of the artificial dye. Yet another method of mordanting is to dye first with a direct cotton colour of the same shade.

On wool the basic colours are now of comparatively small importance, as the acid dyes have supplanted them to a large extent. The basic dyes are always dyed on wool in a neutral bath. Acetic acid is put in if the water is hard, but merely in sufficient quantity to soften the water and prevent the lime in it from throwing down the colour base, whereby the shade would be made unlevel and spotty. Too much acetic acid retards the exhaustion of the bath. Glauber's salt is sometimes used. Silk is dyed in a neutral bath, as a rule, but it may be slightly alkaline or acid without disadvantage. As is usual in silk dyeing, a soap-bath is commonly employed. The goods are entered lukewarm, and the bath is gradually heated to about 200° F., at which temperature the dyeing is finished. The basic dyes are faster on silk than on cotton or wool.

The Hoechst Janus dyes belong to this group. They were introduced in 1897, and are azo dyes, which are remarkable for dyeing cotton, wool, and silk direct from acid baths.

Acid Dyes. These are salts, and the colour has to be liberated by the addition of acid to the bath. In the case of wool, the fibre may be soured before entering the bath. An average recipe for wool is: dye-stuff, ½ per cent. to 6 per cent.; Glauber's salt 10 per cent.; sulphuric acid, 4 per cent. Enter hot, raise to the boil, and boil from an hour to an hour and a half. Their first representatives were fluoresceine and its bromine derivative, eosine, both discovered in 1874. When first put on the market by Bayer and Caro, eosine was sold at £18 per pound. The acid dyes are mostly soluble in hot water. They can be dyed on cotton with the ordinary mordants, but they are not much used. The acid dyes have less tinctorial power than the basic dyes. The average amount of dye needed for a fairly full shade may be put at 3 per cent.

On silk the acid colours are used exactly like the basic, except that the baths are usually made more acid, and that lower temperatures—say, 140° F.—are employed to check any tendency to want of uniformity. Silk has little affinity for the acid dyes. It is as substantive dyes for wool that the acid dyes find their chief application.

Some of the dyes, such as chromotropes, chrome brown and alizarine yellow, are fixed with chromium fluoride, alum, or bichromate, added either at the end of the dyeing to the dye bath itself or applied to the dyed fabric in a separate vat. A few acid dyes, such as eosine and phloxine, require the use of acetic instead of sulphuric acid, or the resulting shades are wanting in brightness.

The bath made with the acid dyes exhausts well on wool—that is, it parts with almost all the dye and can be run off. If sufficient acid to exhaust the bath has not been added to begin with, the ordinary expedient is to add more towards the close of the operation.

Many garment cloths are now woven with white or coloured "effect threads" of cotton. When dyed in the acid bath these threads do not take the colour, or to such a small extent that it is eliminated in the subsequent washing.

Mordant Colours. This group is divided into two classes—the ordinary mordant dyes and the acid mordant dyes. The latter behave as acid dyes after heating with a metallic salt or oxidation with bichromate of potash and sulphuric acid, with or without the addition of Glauber's salt. The ordinary mordant dyes are substances which have the power of combining with the oxides of various metals, forming insoluble lakes, and the use of these dyes depends upon the formation of the lake upon the fibre.

The general method of the application of the acid mordant dyes is to mordant and then dye the material with them at the boil with sulphuric acid and Glauber's salt, and when the bath is exhausted

to allow it to cool to about 150° F., when the bichromate is added, the goods being lifted the while. The dyeing is then resumed and continued for about half an hour longer. If more than one dye is in use, those should be chosen which require the same mordant.

Mordant Processes. With the ordinary mordant colours the processes may be classed as two-bath and one-bath. In the former the dye and the mordant are used in separate baths, sometimes the dyeing preceding the mordanting and sometimes the reverse. In the one-bath process the mordant and the dye are used in the same bath. The chief mordants used are various salts of iron, aluminium, and chromium.

A highly important class of chrome colours for wool has lately been very largely used which can be dyed in any one of three ways: (1) by mordanting with chrome and dyeing; (2) by dyeing in a single bath with chrome and colour; (3) by dyeing first and after-mordanting with chrome. Some of these give the best results with one only of these three processes. A well-known class of these dyestuffs are known as the metachrome colours.

One of the most important branches of mordant dyeing for cotton is alizarine dyeing. To get alizarine Turkey-red on cotton various methods are employed. The goods are first impregnated with Turkey-red oil, dried, and steamed. They are then dyed with from 5 per cent. to 20 per cent. of dye, and a little acetic acid if the water is hard. They are entered cold, and the bath is very slowly heated to nearly boiling point and kept at that temperature until exhausted. The goods are wrung, rinsed, and dried, and mordanted in a fresh bath, the mordant being selected according to the colour wanted. If the mordanting is to precede the dyeing, the metal must be fixed on the fibre by a bath intercalated between the mordanting and the dyeing baths. One method is, after treatment with Turkey-red oil, to wring the goods, and then dry them at a moderate heat (about 130° F.). They are then given several hours in a bath of basic sulphate of alumina, made by dissolving alum in hot water and adding crystals of carbonate of soda when cold. Add 1 lb. of the crystals for every 4 lb. of alum; then fix the alumina in a bath of chalk or phosphate of soda, and dye. In this process the dye-bath must contain lime.

Erban and Specht were the first to dissolve the dye in a solution of ammonia, fixing with alumina, and this was found to be a useful process. For dark shades aluminic acetate is used and converted into the basic insoluble form by subsequent steaming. For light shades aluminate of soda is used. In this case the steam has to be accompanied by acetic acid to form the basic acetate. Linen is treated as cotton.

Lately the modern vat dyes have come into severe competition with alizarine, which very easily supplanted madder. The old Turkey-red dyeing with this natural dyestuff was specialist work, slow, complicated, and even dangerous.

Mordant Colours on Wool. For wool with the mordant colours a common mordanting bath is bichromate of soda to which a reducing acid, such as lactic, formic, or acetic, has been added. The chromium is deposited on the fibre as sesquioxide, and at once forms the lake when the goods are entered into the dye-bath. About 3 per cent. of bichromate is used for dark shades, less for lighter ones. The amount of acid is rather less. With chromium fluoride, use 2 per cent. to 4 per cent., and 1 per cent. to 2 per cent. of oxalic acid. When alumina is used, the bath is made with 5 per cent. to 8 per cent. of sulphate of alumina, or 6 per cent to 10 per cent. of alum, and 3 per cent to 8 per cent. of tartar. This bath should be rather long (say, forty times the weight of the wool). If there is too much alumina present, the wool absorbs acid as well as alumina, and the shades on dyeing will be deficient in colour and fastness. If there is too little alumina the colours will be loose to rubbing. The baths must be absolutely free from iron or copper. Iron is a common impurity of alumina salts. Work the wool in the bath—cold—for about 15 minutes. Then boil up and boil about one hour or rather less. Then dye. When iron is used, the bath is made with 3 per cent. to 5 per cent. of ferrous sulphate, and 2 per cent. to 3 per cent. of tartar, or 1 per cent. to 1½ per cent. oxalic acid.

In dyeing wool with some colours, for instance, alizarine WS, the process is different. A bath is made with 10 per cent. of Glauber's salt and the dye. After the wool has been boiled in this for half an hour it is lifted, and 4 per cent. of sulphuric acid is added to the bath. The wool is re-entered and boiled for another half an hour. Then the iron, chrome, or alumina mordant is added, and after 45 minutes' more boiling the process is finished.

Mordant colours are too expensive for silk, as a rule, but, when used, alumina is the chief mordant, as silk is difficult to mordant with chromium.

Besides alizarines, this class includes some of the anthracenes, such as anthracene brown, flavopurpurine, chrome fast yellow, galloflavine, diamond blacks, gallamine blue, and chromo-cyanine.

Insoluble Colours. The insoluble colours can be divided into two classes—those which are added to the dye-bath in the usual way, but must be reduced, like indigo, or require a special solvent other than water to dissolve them, and those which are produced on the fibre. It might at first seem that the mordant dyes ought to fall into this second class, but, although the actual colour produced is undoubtedly affected to some extent by the nature of the particular mordant, yet in the case of the mordant colours a previously existing dye is employed, and the resulting shade depends mainly upon it, whereas in the case of the developed colours the dye is wholly manufactured on the fibre, so to speak.

The first class is represented by the sulphur dyes and the vat dyes, and the second, which may conveniently be styled that of the *developed colours*, may be divided into aniline black, paranitraniline red, and other diazotised colours.

Sulphur Colours. Canarin, discovered in 1821, might be ranked as the first of the sulphur colours, but it is an inorganic salt prepared by oxidising potassium sulphocyanide. The first of the organic sulphur colours (also called *sulphine* or *sulphide colours*) was Cachou de Laval, made in 1873 by fusing sodium sulphide with various organic bodies, such as bran and sawdust. It was followed much later by Vidal black (1893).

The great fastness of the sulphur colours is now bringing them rapidly to the front, although their use is at present almost confined to cotton dyeing. The dye is dissolved in sodium sulphide solution, and an average dye requires its own weight of sodium sulphide. Extra marks, however, require twice their weight, and the highly concentrated brands treble. Until quite recently these dyes have been put upon the market in a very impure state, so that enormous percentages of them were

required, but this state of things is now much improved. Some of the very concentrated marks give full shades with 5 per cent., or even 4 per cent.

The bath must be made with Glauber's salt and also carbonate of soda (soda-ash) to increase the affinity between the dye and the cotton. Various special precautions have to be taken. Wood only must be used for the dye vat. The goods, although entered at the boil, should not be allowed to boil in the bath. Steam should be shut off as soon as the goods are in. During the dyeing the goods must be kept immersed, as contact with the dye and with the oxygen of the air tenders the fibre, and at the same time tends to make it assume a bronze appearance.

As regards the quantity of sulphide of sodium to be used, the best rule is to put just enough to dissolve the dye. The colour will come out very thin if any notable excess of the sulphide is used. The bath is kept standing, and reinforced with dye and sulphide as may be required. The dyed goods are centrifuged, rinsed, and fixed with bichromate and sulphuric acid, with sulphate of copper or peroxide of hydrogen, or by steaming. Overaction of the fixing agent must be avoided, as it tends to weaken the material. In all cases the goods are rinsed free from fixing agent and then soaped to neutralise any excess of acid, and also to take away the harsh feel left in the fibre by the dyeing. When the soap has been rinsed out nothing remains but to dry the goods.

Sulphur Dye-baths. A very essential precaution in dyeing with the sulphur dyes is to use baths as short as convenient. While the average cotton-dyeing bath has twenty times the weight of the goods, it should be restricted to about twelve times the weight in the case of the sulphur dyes. In some cases a simple air oxidation suffices to fix the colour, so that the dye can be used like indigo. Such dyes are much preferred, and naturally so, as not only does the fixing in other ways cost time and money, but almost always alters the shade, thereby making it difficult to dye to pattern. There are already more than 200 brands of sulphur dyes now upon the market, and the range is daily increasing. To begin with, black was the only colour producible with the sulphur dyes, but the makers gradually added grey, brown, olive, blue, yellow, red, and violet. The range of shade producible with sulphur colours is now almost complete.

The chemical constitution of the sulphur dyes is not accurately known—*i.e.*, the correct formula cannot be stated. In 1906, however, a very remarkable dyestuff was put on the market under the name of thio-indigo-red B, which had a distinct chemical formula and may be regarded as an artificial indigo in which the two imido groups are each replaced by an atom of sulphur. It therefore has the relationship with indigo on the one hand, and with sulphur colours on the other. Thus it may be reduced, like indigo, in the vat, or dissolved in sodium sulphide solution like a sulphur colour. The range of pink to red shades that it gives has notably assisted to complete the series of sulphur dyes. The dye combines well with indigo, with the other sulphur colours, and with basics, thus giving a range of shades with remarkable qualities of fastness.

Vat Dyes. By "vat dyeing" is understood a process in which a matter insoluble in water is reduced to its leuco—*i.e.*, colourless—base in the dye-bath, and is reproduced upon the fibre by oxidation. Thio-indigo-scarlet quickly followed thio-indigo-red, the remarkable dyestuff described in the preceding paragraph, and in this only one of the imido groups is replaced by sulphur. It is used in the hydro-sulphite vat, and was quickly followed by a highly important group of vat colours used in the same way, the fermentation vat employed for indigo being less suitable and much more difficult to manage. In addition to many brands of artificial indigo these vat dyes now include a perfect gamut of tint and colour. The most important are the ciba, hydron, helindone, and indanthrene colours.

Vat dyeings on cotton are fast to alkali, washing, light, and chlorine. Among the fastest are the carbazol group. Hydron blue of this group can compete with natural indigo when dyed on cotton.

The vat dyes are also very important in linen dyeing, as they give the fibre very fast colours at temperatures low enough to prevent tendering.

On wool the dyeings of suitable vat colours are as fast as on cotton, and the wool is not in the least damaged by the dyeing process. Loose wool or slubbing is much easier to spin than when dyed with any other class of dye.

The only fault of the vat dyes is their high cost. This is compensated for, however, by the manner of use, as they are chiefly employed for embroidery, or for the warp threads of shirtings dyed in light shades. For these purposes they have the advantage of being extremely fast to washing. They may go to the laundry again and again without even showing any change of colour, and they will even withstand a mild bleach.

Azo Colours. In 1880 Read Holliday & Sons, of Huddersfield, patented a process for forming azo colours direct on the cotton fibre. The soluble azo colours are not cotton dyes, as no mordant has been found to fix them on this fibre, but Messrs. Holliday showed that they could be *made* on the fibre. The principle of the process of producing an azo dye is this. An amine, such as naphthylamine, is taken, dissolved in hydrochloric acid, and then diazotised by treatment with sodium nitrate; the diazo compound so produced is then combined with a phenol or an amine, and a colour is produced. This may then be treated with sulphuric acid, and thus converted from an insoluble to a soluble form. Messrs. Holliday, in their process, caused the cotton fibre to be impregnated with a solution of the amine; the fibre is then passed through an acid bath of sodium nitrate, whereby the diazo compound of the amine is produced on the fibre, which is now passed into another bath containing an amine, or phenol, or some other body capable of combining with the diazotised amine to form a colour—what this will be depends upon the amine that has been used.

At the time little use was made of the discovery, and attention was urged to it once again when another English chemist created a sensation in the dyeing world.

Primuline, already mentioned as a direct cotton colour, dyes unmordanted cotton a primrose yellow. Mr. A. G. Green made the remarkable discovery, in 1887, that by diazotising primuline on the fibre with nitrous acid, followed by a treatment with a phenol or an amine, a range of very fast and beautiful colours was produced, varying with the developer used, for instance:

Beta-naphthol	gave red.
Beta-naphthol-di-sulphonic acid R	,, maroon.
Resorcinol	,, orange.
Phenol	,, yellow.
Meta-phenylene-diamine	,, brown.

As these were produced in the fibre they were called "ingrain" colours, and the Germans call this class "ice colours," as a very low temperature is necessary for the diazotising bath.

As already mentioned, some direct dyes are advantageously diazotised and developed in this way, notably many of the diamines. This process increases the intensity of the dyeings or effects a change of shade. In either case the dyeings are improved in fastness to washing, and frequently also in fastness to light and cross dyeing.

An analagous process is known as "coupling." Diamine colours, for instance, may be coupled on the fibre with nitrazol or paranitraniline, with a resultant increase of fastness to washing and milling, and in some cases the resistance to light and cross dyeing is also improved. The cold coupling bath is charged with a solution of nitrazol or diazotised paranitraniline, soda and acetate of soda, and the dyed and rinsed cotton is treated in it for a period of half an hour.

Insoluble Azo Dyes. As regards the insoluble azo dyes, however, the number in use is very limited, but at least one, paranitraniline red, familiarly known as *para red* in the dyehouse, is highly important. It is produced by steeping the goods in a solution of beta-naphtholate of soda—that is, a solution of beta-nephthol in caustic soda, usually with the addition of Turkey-red oil—drying and developing at once. The developing bath is made by dissolving paranitraniline in a hot solution of hydrochloric acid. Cold water is added, and when the bath is quite cold nitrate of soda is added. Naphthylamine claret is the next most important insoluble azo colour. It is prepared by diazotising alpha-naphthylamine. Effective means of discharging it on the fibre to produce white and coloured patterns have been discovered. Dianisidine blue is obtained by developing dianisidine with beta-naphthol.

Toluidine orange, amido-azo-toluol garnet, and a few other insoluble azos have found limited uses and are produced in a similar way.

Aniline Blacks. Aniline black is generally divided into two classes—oxidation blacks and steam blacks. The formation of aniline blacks depends upon the oxidation of aniline. Its use is practically confined to cotton, because wool and silk, having reducing properties, seem to prevent the oxidation of the aniline. It is possible, by a previous treatment of the animal fibre, to remove the difficulty, so that afterwards the aniline black can be applied by the same processes as for cotton. The most successful process is to fix Prussian blue on the wool or silk, alone or in mixture cloths, then dyeing with any aniline black.

Cotton is dyed in various ways with aniline black. When the oxidation is effected by a liquid the black is called an "oxidation black." When, however, it is effected by air aided by steam, the black is a "steam black."

Oxidation Black. The following is a method of preparing an oxidation black: Make the bath with 40 per cent. hydrochloric acid (34° Tw.), 10 per cent. aniline oil, and from 10 per cent. to 14 per cent. bichromate of potash. The bath should weigh about sixteen times as much as the cotton. The aniline is dissolved in the acid and the bichromate in water first. The aniline is first added to the rest of the water, and then the bichromate. The cotton is worked cold in the liquid for an hour. When the colour of the cotton is fairly strong, heat up the bath slowly to 140° F. to 150° F. At least three hours should be occupied in the dyeing, as the slower the process is the less chance there is of the black turning green on exposure to the air. On lifting the cotton it is well rinsed, soaped, and rinsed again.

Steam Black. Dissolve separately 6 per cent. aniline oil, 9 per cent. hydrochloric acid, and 12 per cent. sulphuric acid in 200 per cent. of water. Dissolve separately 12 per cent. of sodium bichromate in 200 per cent. of water, and mix the two solutions. Enter the cotton cold, and as soon as it is dyed, which takes two or three minutes, wring it, and steam for twenty minutes at 14 lb. pressure.

Prevention of Greening. Cotton dyed aniline black by either of these processes is usually given an oxidising bath of bichromate and sulphuric acid as a precaution against greening, but the black is sometimes topped with methyl violet with the view of concealing any greening that may actually happen. Sodium chlorate is also used as an oxidising agent in the production of aniline black, especially on piece goods, but it requires the assistance of other agents. Lightwood used chloride of copper as an oxygen carrier, and ferrocyanide of potassium has also been employed. Probably the best yet known is ammonium vanadate or vanadium chloride.

The cotton is impregnated, for example, with 5 per cent. to 20 per cent. of hydrochloride of aniline, 2 per cent. to 10 per cent. of chlorate of potash, and a very small quantity of the vanadium salt (about three-thousandths of the weight of the aniline salt). The black is developed by oxidation in a current of air kept damp by steam, and passing over the cotton at a temperature of about 80° F. A much better and quicker development is obtained by the use of the Mather & Platt, in which the goods are passed through hot steam in a closed chamber. The temperature used depends upon the kind of black in question, being about 200° F. for ferrocyanide black, but for Lauth's sulphide of copper black about 160° F. only.

Artificial Indigo. The artificial synthesis of indigo is of decidedly earlier date than the putting of the product upon the market, but for a long time the cost of its manufacture prevented it from competing with the natural dye. In 1870 Baeyer and Emmerling made it from coal-tar products until 1878. In 1880 Baeyer prepared indigo from cinnamic acid, and in 1882 Baeyer and Drewson prepared it from orthonitro-benzaldehyde by the joint action of acetone and caustic soda. This artificial indigo was put on the market in 1893, in combination with hydrosodic sulphide, under the name of indigo salt, by Kalle & Co. Another synthesis of indigo, from phenyl-glycocoll, by Heumann, was published in 1890. The process belongs to the Badische Anilin und Soda Fabrik, and forms the basis of the method by which that company now prepares its indigo rein (indigo pure), which was put on the market in 1897. All these artificial indigos are identical with one another, and with the indigotin of the natural dyestuff.

Operations Preliminary to Dyeing. Even if goods are to be dyed in the grey state they must pass through a preliminary treatment before they can be properly dyed. They have gathered grease and dirt in the process of spinning and weaving, and the wool has been purposely oiled, and the cotton warps have been stiffened with size, which will act as a resist to the dye. The goods, therefore, must be bleached, or thoroughly scoured, or wetted out.

In these and in the dyeing processes the quality of the water used is of the first importance. A vast volume of it is required in the dye-houses, and an abundant supply of pure water is a prime necessity.

The subject of softening and purifying water has been treated on pages 3430 and 5451. Here it is sufficient to say that the dyer requires "soft" water, and even a trace of iron in it would be fatal to his operations. As the preliminary operations and, in particular, bleaching vary with the different fibres, we must consider them under the headings: Cotton, Wool, and Silk.

Wetting Out Cotton. The grease and dirt is removed in this operation with a mild alkali, and the fibre is uniformly impregnated with water in order to allow the dye to penetrate it evenly. Air-bubbles in the fibre are quite sufficient to cause uneven dyeing, and these are removed in wetting out. The usual method is to boil the goods with water containing 2 lb. or 3 lb. of soda-ash per 100 lb. of goods. The addition of a pure, well-made soap assists the operation. In some cases the wetting out is done in the machine used in dyeing. For instance, raw cotton, and sometimes hanks and warps, are treated with boiling water for half an hour, or more, in the machine before the dye-bath is made up, and piece goods are given a few ends through boiling water on the jigger. More frequently a boiling-box or low-pressure kier is used. Sometimes water alone is used—for instance, in cases where the dyestuff to be used would be affected by the soda—and in some cases it is advantageous to substitute a smaller proportion of caustic soda. This is quite sufficient preliminary treatment, as a rule, for dark shades.

Bleaching Cotton. The most perfect bleach is naturally needed by the calico printer, and in some cases, even for light shades, the dyer is content with steeping the goods already wetted out in a weak bath of bleaching powder, without heat, for a few hours, washing, souring with dilute hydrochloric acid, and washing thoroughly.

Bleaching is discussed in the course on TEXTILES, to which the reader is referred [see page 3259]. It is sufficient to remark that the dyer and calico printer is frequently satisfied with a less perfect bleach than when the goods are to be put on the market as "whites."

Singeing. This is a step of the bleaching process, especially when the cloth is to be printed, but frequently it is advisable to singe goods to be dyed in the grey, and it is a necessary process in lustre mercerisation and schreinerising. When yarn has to be singed, as, for instance, in the case of fine counts that are to be given the appearance of silk, either by mercerisation or by a mechanical process, this is a work of the spinner, who "gasses" the yarn—that is, passes it at a high speed several times through the flame of a Bunsen burner. Many forms of machines are used for cloth, and the singeing is done by coal, coke, or gas, and even electricity has been tried. Sometimes the cloth is passed over a hot plate heated by fuel, and at one time the difficulties in the way of employing the direct flame of the gas for cloth singeing made the plate machine the principal one used for the purpose.

Wool. Wool "in the grease"—that is to say, as it is obtained from the sheep's back—in addition to dirt, contains a heavy percentage of fatty bodies insoluble in water, called "suint," consisting principally of potassium salts of organic acids. As these are removed before spinning, however, this is not the dyer's business, and is treated in TEXTILES [see page 2213]. The woollen spinner, however, is obliged to oil the wool in spinning to give it suppleness, and, whether from the yarn or cloth, this must be completely removed before dyeing or bleaching. This is a simple enough operation if good olive oil has been used, but much trouble in the dye-house has resulted from the use of mineral oils, which are unsaponifiable.

Scouring. The yarn is scoured in a solution of soap alone, or of soda and soap, but the bath is not heated above 110° F. It is frequently done by hand, the hanks being hung on sticks as in dyeing, worked in the same way. When sufficiently scoured the yarn is washed thoroughly, squeezed, and dried. Cloth is not always scoured before dyeing when it is to be dyed black, but for the best work it is always necessary. A very ordinary form of machine is the "dolly." This practically consists of a pair of squeezing rollers revolving over a tank containing the bath of soap and soda. The pieces are sewn together in a continuous band, and passed in rope form—that is to say, not opened out—through the bath by means of guide rollers, and through the nip of the squeezing rollers. The scouring is continued until the pieces are perfectly clean. Setting, crabbing, and bleaching, all necessary preliminaries to dyeing, are described in the course on TEXTILES.

Silk. The object of the preliminary operations in this case is not only to prepare the material for dyeing, but also to make it soft and lustrous. This is done by removing more or less of the silk glue, and, according to the degree to which this operation is carried, the material is called "boiled-off silk," "souple silk," or "écru."

Boiling Off. The silk is worked for an hour rather under the boil in a bath made with about 30 per cent. of soap. The gummy, soapy liquor that results is known as "boiled-off liquor," and is used in the silk dye-bath. The silk is then washed in water in which a little soda-ash is dissolved, and scoured. For this process the silk is put into hempen "pockets" and boiled, sometimes as long as three hours, in a soap solution about half the strength of the previous bath. It is then washed thoroughly in soft water, and dried.

Soupling. The raw silk is first scoured by working for about an hour in a lukewarm bath made with about 10 per cent. of soap and a little soda. It is then worked in a solution of aqua regia in a stone trough, bleached after the manner of wool by sulphuring, and, without removing the sulphur, is softened by working in a solution of cream of tartar at about the boil, or a little under. The process requires experience, and should be studied in works like Hurst's "Silk Dyeing."

Ecru Silk. This is simply scoured in a lukewarm bath of soap and soda. This removes the fats, but very little of the gum. In this state it may be dyed black, but for other colours it is bleached.

Bleaching. Silk can be sulphured in the same manner as wool, but the white obtained is very fugitive. The best agent is peroxide of hydrogen or perborate of soda. The scoured silk is simply treated in an alkaline bath of peroxide. It is entered cold, left for twelve hours, and then the bath is made lukewarm, and the process is finished in another three hours. This is slow, but an unhastened cold bath is better in peroxide bleaching, whether for wool or silk.

ARTHUR MORRIS

The Railway Clearing House and Its Work. Science in Modern Railway Work. Legal and Sundry Departments.

MINOR RAILWAY DEPARTMENTS

UNTIL the year 1842 the working of through traffic—that is, traffic originating on one line and passing over one or more continuous but separate line or lines—was cumbrous and vexatious, each company collecting its own tolls and keeping its own accounts. In that year Mr. Kenneth Morison propounded and successfully inaugurated his clearing system, by which the foreign or through traffic of the companies is accounted for by the terminal companies interested to the Clearing House, the companies receiving their relative proportions through that channel.

The Railway Clearing House. The Clearing House performs a kind of work which could not have been performed by the companies, no matter how amicably disposed towards each other they might have been. It maintains perfect accord among all manner of conflicting interests. Once a party to the Clearing House system, a company knows it must abide by its decisions. However, any company may withdraw at will by giving one month's notice under seal, or a company may be expelled by the votes of two-thirds of the delegates present at a meeting specially convened for the purpose.

The travelling public seldom realise how much they owe to the clearing system, for by means of this institution they, both as freighters and passengers, are saved much trouble and annoyance. For example, a passenger can book for a journey, say, from Penzance to Wick, and one little piece of pasteboard franks him over several separate and absolutely distinct railway properties. Without the system he would be burdened with a book of coupons, to vouch him over each railway in turn, or might even be compelled to take a fresh ticket at every junction of the different companies' lines.

The Growth of the Clearing House. Like most great institutions, the Railway Clearing House had a very humble beginning, for, writes Sir John Findlay, "it began its operations with a staff of only four clerks, and dealt with the traffic of only four railways, controlling an aggregate mileage of 418 miles; but its growth has only been paralleled by the growth of the railway system itself." Every railway of importance is now a party to the Clearing House, the clerical staff of which numbers upwards of 2500, while there are, in addition, some 500 "number-takers" employed up and down the country, whose business it is to examine and report upon the vehicles of trains passing through important junctions. The original home of the Clearing House was a small house in Drummond Street, near Euston Station, but before many years had elapsed its operations attained such magnitude that a move was made to its present home, the huge building in Seymour Street, N.W. England and Scotland are represented in the institution in Seymour Street, while Irish business is transacted in the same form at the Irish Railway Clearing House in Kildare Street, Dublin, which was established in 1848. The work of the Railway Clearing House is divided into departments, of which the three largest and most important are as follows: the Merchandise, the Coaching, and the Mileage Departments.

The Work of the Merchandise Department. The Merchandise Department is charged with the apportionment month by month of the receipts derived from the carriage of all "through" goods, cattle, coal, and mineral traffic. The department is supplied every month with returns from all stations, giving full particulars of all such traffic. Every station sends in two distinct forms, one concerning the "outwards," or forwarded traffic, which is printed in black, and the other relating to the "inwards," or received traffic, printed in red. These abstracts state the character of the goods, their weight, the rate per ton, the charge, and whether it is "paid" or "to pay," the number of the waggon in which the consignment travels, and the name of the owner of the waggon. The two abstracts are carefully compared, and steps taken to rectify errors or discrepancies between them.

The monthly settlement is arrived at as follows: first, all total receipts between a pair of stations which amount to less than £1 are thrown out and credited to the "light traffic fund." Next, taking the remaining receipts from the traffic which has passed between each pair of stations, the terminal allowances, fixed tolls, and amounts "paid on"—that is, disbursed by the forwarding company for any special service rendered—are deducted. Thirdly, the residue is divided by mileage between the different companies concerned, so that each company gets a due proportion according to the distance it has carried the traffic. Lastly, to obviate a plethora of small accounts, the amounts credited to the "light traffic fund" are divided among the different companies in the ratio of their gross receipts from the heavier traffic.

"Clearing" the Coaching Traffic. The Coaching Department is charged with the division of receipts on all "through" traffic by passenger train—namely, passengers and their luggage, horses, carriages, dogs, parcels, fresh fish, perishables, and the like.

The passenger traffic is dealt with monthly. The booking clerks render every month to the Clearing House a return specifying the through tickets issued, and every stationmaster has to forward to the Clearing House all tickets collected at his station during the month and issued by any company other than his own, save that the tickets in which two companies alone are interested are not checked by the Clearing House unless they are issued and collected by the same company.

The receipts derived from "through" tickets are divided by mileage, but no company may receive out of a through rate more than its local fare, which means that some companies' mileage proportions have to be reduced to their local fares, and the balance divided among other companies whose proportions do not come up to the amount of their local fares. The remaining items in the coaching traffic are settled half-yearly, and here, again, occurs a light traffic fund, this time limited to 5s. On the

parcels, fish, and perishable traffic, terminal charges have to be taken into consideration, whereas no terminal charge is levied on horses, dogs, and carriages. Here it may be noted that it was only by the assistance of the Railway Clearing House that the Post Office was able to establish the Parcels Post under the Act of 1882. The great difficulty that attends this phase of the Clearing House settlement lies in tracing the route by which parcels, etc., have travelled. Theoretically, the way-bills that ought to accompany all parcels, and which are supposed to be stamped at each junction, should explain matters, but parcels and way-bills are apt to get separated, and the stamping of way-bills is frequently omitted.

The Mileage Department and its "Number-takers." The Mileage Department keeps the mileage accounts of the various companies in the matter of rolling stock of one company passing on to the territory of another, and attends to the question of demurrage for detention of carriages, waggons, and tarpaulin sheets.

The staff of "number-takers," whose members are found at every junction of two railways, records the number and description of every vehicle and sheet that passes a junction going from one line to another. In addition, every station receiving foreign stock makes a similar return, which shows how the latter got there and what was done with it. Each company's stock is shown separately under three headings—Carriages, Waggons, and Sheets.

Demurrage Regulations. Revised demurrage regulations by the railway companies of England and Wales were put into operation on January 1, 1913, as follows: Before conveyance, 1s. 6d. per ordinary waggon per day, and 3d. per sheet per day after the expiration of one day, exclusive of the day on which the loading of the waggon is begun. After conveyance, 1s. 6d. per ordinary waggon per day, and 3d. per sheet per day after the expiration of two days, exclusive of the day of arrival. Waggons of special construction or of large capacity are subject to special arrangements.

The Scottish regulations include waggons used for coal and coke traffic, which are specifically excluded from the notice given by the English and Welsh companies, on whose lines coal traffic is almost wholly carried in private owners' waggons, whereas the Scotch railways carry coal as well as other kinds of traffic in their own waggons. The companies also gave notice of their intention rigidly to enforce demurrage charges, which hitherto had been rarely done. The demurrage on coaching stock is 10s. per first-class carriage per day, and 6s. per third, second, or composite class carriage per day.

Clearing House Conferences. These are usually held every three months, and comprise the following: Goods managers, to discuss classification of goods rates, mileage charges for the use of waggons, construction of private owners' waggons, and similar matters; superintendents, to deal with the speed and signalling of traffic, rules and regulations relating to the safe working of the lines, excursion facilities; general managers, to review the recommendations of the former conferences, and then to frame proposals to be submitted to the committee of delegates for their adoption.

Organisation and Staff. The Clearing House business is regulated by a chairman, elected annually, and by committees of the traffic officers of the various companies—the general managers, goods managers, and superintendents—who sit once a quarter at the Clearing House premises. The two last classes of officers sit in the same week on separate days, and the former a few weeks later, to revise and approve the minutes of proceedings.

The working expenses of this vast and admirably managed organisation, which makes no profit and incurs no bad debts, are borne by the companies in the ratio of the business done on their behalf.

To obtain a junior or apprentice clerkship in the Railway Clearing House, application must be made to the secretary, and approved candidates have to pass an ordinary clerkship examination. The Clearing House "number-takers" join the service as lads, after they have been medically examined as to sight and physical soundness. Lad "number-takers" are posted to one or other of the junctions where waggon numbers are recorded, and begin to learn their duties by making out returns. Subsequently they are put to work in the yards under older hands.

The Chemist and the Railway. The chemist has always filled an important rôle in the locomotive department of a railway; and when it is considered that this department—with which, as a rule, is incorporated the carriage and waggon department—forms the great spending arm of a railway company, it becomes easy to understand how he should be the man to whom the locomotive engineer looks to point the way towards effecting economies. Every day the scientific side of the railway profession is coming more to the front, since an increasing number of solutions of questions capable of definite scientific treatment is constantly being discovered. Thus there are more and better openings for railway chemists, while the field of employment is no longer confined to a locomotive department laboratory, but also embraces that of a general engineering chemical laboratory. The two laboratories are, however, kept distinct, for although many of the chemical and physical investigations which are performed therein cover the same ground, the object in each case is different, necessitating a different kind of analysis. For example, there is the scrutiny of water. In the locomotive laboratory the chemist is concerned only with the quality of the water for feeding boilers. He has to examine it in order to see that it does not contain an undue proportion of chalky matter, which would deposit scale upon the tubes and firebox plates, and so impair their efficiency as conductors of heat from the furnace to the water. Again, he analyses it to see that it does not contain any corrosive salts, such as magnesium chloride, which would cause the structure of the boiler itself to be corroded.

Scope of the Engineering and Locomotive Laboratories. In the engineers' laboratory the chemist has to concentrate his attention upon the suitability of the water supply for domestic purposes. A railway company owns hundreds of cottages and houses up and down the line for housing its employees, and all these dwellings must, of course, be supplied with a pure water supply, suitable for both human consumption and domestic purposes. And the same rule holds good in the case of stations.

The examination of the different kinds of oil for the lubrication of the locomotive is a most important feature of the locomotive chemist's duty; and the other sorts of oil which are employed in the paint-shop for mixing the paints and varnishes used to protect and decorate the outer surface of engines and rolling stock likewise demand

his attention. The engineers' chemist also deals with oils—those for the paints used to cover all woodwork. Then photometric work is common to both establishments. The locomotive chemist tests the oil for the signal lamps, together with the gas-burners and incandescent mantles for the lighting of the carriages, while the engineers' chemist investigates the qualities of every means of illuminating stations and offices. The efficient lighting of station premises is a subject in which advertisers have a direct interest.

Things which concern the locomotive chemist alone are the steel analysis and metallurgical work generally, in the case of those railway companies which have their own steel-works ; the analysis of pig iron, coke, and various other materials for the iron foundry ; the analysis of copper-plate for fireboxes, copper tubes for the locomotive boiler, and bronze bars for firebox stays ; the analysis of the materials for bearing brasses and bronzes, and the examination by combustion in a calorimeter of the coal by means of which water is to be converted into steam to propel the trains. The coal for the locomotives must not contain much fusible ash, otherwise it is liable to choke the fuse-ends in the firebox and prevent the boiler from steaming properly. The composition and quality of its ash, together with its heat-giving qualities, can be determined only by an exhaustive calorimetric test.

The engineers' chemist has his own peculiar field in analysing the creosote for sleepers and the cement for buildings, while some companies ask him to conduct the most searching investigation in regard to broken rails.

The Inquest on Fractured Rails. The London and North-Western is the only railway that rolls its own rails. The plant at Crewe has a capacity for turning out 45,000 tons of rails annually, the mill being driven by a 700-horse power engine. In the purchase of rails from private manufacturers, a company's inspector has the lot laid out on a bank, in order to scrutinise each rail. Quite 30 per cent. are rejected or sent back to be straightened ; but, of course, the inspector cannot detect inherent flaws. To ascertain the cause of the latter, the following procedure is adopted. The fractured rail is sent to the engineers' laboratory, accompanied by a report from the district engineer, stating the date when discovered (a ganger finding a broken rail is suitably rewarded), and the locality ; whether the rail belongs to an " up," " down," or a single line ; particulars of the fracture, accompanied by drawings ; the distance of the fracture from the nearest bearings on each side, and the distance from the nearest joint ; if in the double line ; whether on the leading or trailing side of the nearest side ; if the rail was on curve, the radius of the curve, and whether on the inside or outside of the curve ; the period the rail had been in use ; the average number of trains passing over it per day ; the section ; the weight per yard when new, the actual weight per yard at date of fracture ; the loss of weight per yard, and whether the rail had been turned or not. The chemist cuts two slices as near as possible to the fracture, and if it is a long split the slices come right across it. One slice he polishes, and then etches with 20 per cent. of sulphuric acid for two hours at 60° C. The slice is next photographed, and from its appearance he selects portions of the other slice for microscopic examination, taking a piece from the centre of the head, a piece from the web, a piece from the side of the head, and a piece from near the running edge. These pieces are polished, etched with sulphuric acid, and photographed under the microscope. The rail is also analysed chemically, drillings for analysis being taken either from close to the fracture or from one or other of the slices. Finally, a detailed report, illustrated with microscopic photographs, is forwarded to the chief engineer.

The Evils of Hard Water. There is now no feature of locomotive operation and construction which constitutes so great a problem as the maintenance of boilers, and this is intimately associated with and affected by the character of the feed water. When hard water is evaporated in a boiler, the incrusting impurities are deposited inside the boiler, or on the boiler tubes in the form of scale. The accumulation of this scale not only increases the cost of fuel, but, by placing insulation between the boiler and the water, allows the sheets and flues to become overheated, subjecting them to extremes of expansion and contraction. Then, too, it is necessary to shut down the boiler once or twice a week to remove the scale by " washing out," which operation is referred to in the section dealing with the work of the enginemen. Again, corrosive salts, such as magnesium chloride, in hard water cause the structure of the boiler itself to corrode, thus shortening its life.

Water-softening for Railway Purposes. Of necessity, railways have located their watering stations where there is an abundance of water, without regard to its quality. More recently, however, the keen competition of new industrial conditions has led progressive managers to appreciate the immense saving that can be effected by having a soft water for use in boilers. To secure the best and most economical results from water to be transformed into steam, it must be softened —that is, freed from scale-forming impurities. Considerable attention has been lately devoted to the subject, and different systems of water softening are now being adopted. Many large plants have already been established at important locomotive centres in this country—notably, on the North London Railway, outside Broad Street Station, where it is stated that no less than 70 tons of deposit are collected annually ; on the Great Western Railway, at Goring, where the water for the track troughs is pumped from the adjacent river, and at Aldermaston, near Reading ; on the North-Eastern Railway, at Hessle, near Hull ; and on the Great Central Railway at Mexborough.

Water-softening Machines. In one quite common type of water-softening machine the water is mixed with the proper quantity of chemicals, common slaked lime and soda ash frequently being used, and the mixture is permitted to stand in large tanks by the side of the track until the solid hardening matter thrown out of the solution by the chemicals settles. The clear, softened water is then drawn off through a suction pipe attached to a float, and stored in a supply tank. After weeks of use it becomes necessary to remove the precipitated solid matter from the reservoirs, and this is accomplished by diluting it with hard water, and permitting the mixture to run off through a wastepipe in the bottom. The cost of operating the plant depends largely upon the amount of chemicals necessary, which in turn depends upon the character of the impurities in the water. Even where the water does not contain scale-forming or corrosive impurities, it has been found conducive to longevity and good work in a locomotive to subject the water to chemical treatment.

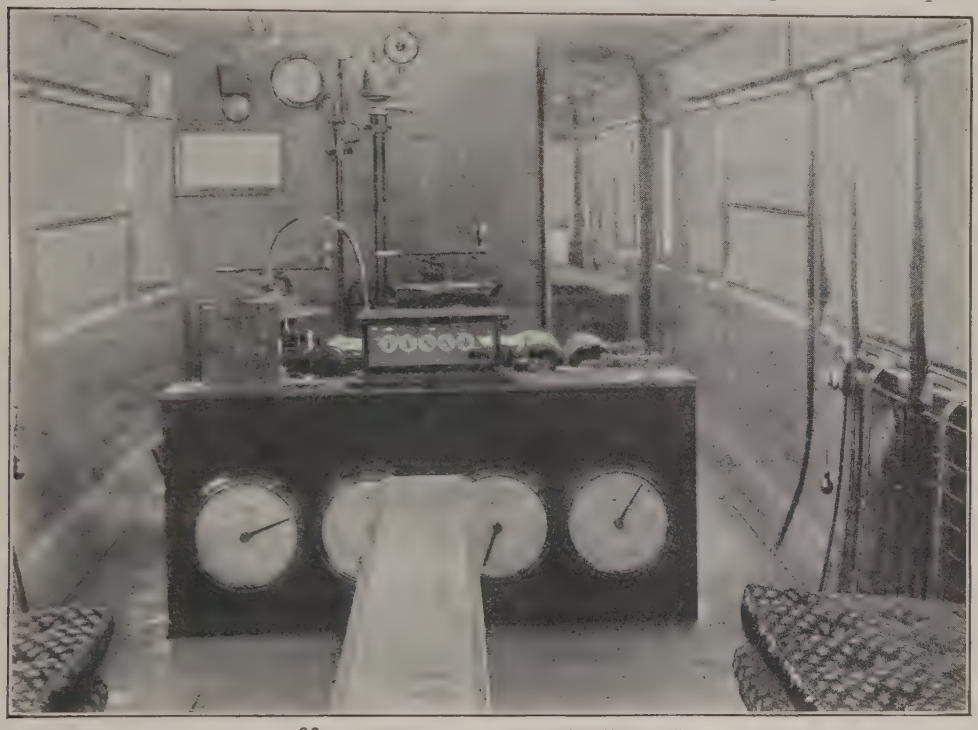
The Kennicott Water-softener. The Kennicott water-softening plant, which is in operation at Severn Tunnel Junction on the Great Western Railway, is capable of treating 30,000 gallons of water per hour. One man in half a day can give all the attention that is needed for a perfect operation of a softener with a capacity of 10,000 gallons per hour. The chemical reagents are hoisted automatically to the top of the machine, where are found the necessary receptacles for dissolving them, and the apparatus for automatically varying them in proportion to the quantity of water entering the apparatus. In the latest type the gear which proportions the chemicals does not come into contact with them. Only water is measured, and this measure and water proportions the chemicals. This represents a very important advance towards increased simplicity and accuracy. Surmounting the cylindrical steel tank is the water-wheel, over which the hard water is first pumped on its way into the softener.

The possibilities for economies that exist in the use of the water-softening system, such as we have described, for removing the scale-forming impurities from the boiler-feed water are almost beyond comprehension. The time for imperfect and incomplete methods, such as by using "boiler compounds" in any form, or by employing any treatment wherein the precipitation of the scale-forming solids is not accomplished, and the material removed from the water before the water is delivered to the motive tender, has passed.

Dynamometer Car Tests. In order to ascertain the tractive force exerted by a locomotive, several railway companies—namely, the London and North-Western, Great Western, and Lancashire and Yorkshire—employ a dynamometer car [90], which is a long saloon coach, replete with a number of complex and ingenious recording apparatus, which are described below.

The indicated horse-power of a steam locomotive signifies the work done in the cylinders or the maximum effort in propelling the locomotive itself and overcoming friction. But by means of a dynamometer car the engineer is informed what amount of power is available for hauling a given load, inasmuch as the actual work being accomplished by the locomotive is then indicated by the pull on the drawbar, coupled with the rate of speed. Thus valuable comparative data for testing the relative efficiency of locomotives are arrived at.

Dynamometer Apparatus. In the centre of the car is a specially constructed spring, free from friction. To this spring the drawbar of the car is attached, and in making a test the car is placed immediately behind the locomotive, where the stronger the force of the pull exerted by the locomotive the more the spring of the drawbar is deflected. The centre of the spring is coupled to a bracket, to which a sliding rod carrying a stylographic pen is attached. A similar pen is fastened to a small fixed bracket. When there is no pull on the drawbar, the two pens are in alignment, but when the locomotive is exerting a pull, the former pen is drawn away from the latter. The pens make contact with paper, after the manner of those fitted to self-recording barometers. The paper to furnish the impression of a chart rotates on drums, and so is wound across a table, according to one or other of two scales—namely, 1 ft. of paper to 1 mile on the line, or 2 ft. of paper to 1 mile on the line. An additional flangeless wheel, which can be raised or lowered at will so as to engage with the rail, drives the foregoing, together with all other



90. INTERIOR OF A DYNAMOMETER CAR

rotating machinery in the car. Accordingly, while a test is in progress, the paper is recording the impression of two inked lines. The line drawn by the pen attached to the fixed bracket is perfectly straight, and is known as the datum line, while that drawn by the pen in connection with the drawbar spring is wave-like. The constantly varying distance between these two parallel lines is measured with a special rule, which gives the force of the pull on the drawbar itself in tons and decimal parts of a ton.

It is next necessary to ascertain the rate of speed at which the tractive effort is being accomplished. This can be given approximately by a dial speed indicator, driven off one of the car axles; but to obtain accurate data the apparatus employed is a clock which is in electrical communication with an electromagnet to which another pen is attached. This pen is deflected, and makes serrations in the line that it draws across the paper every two seconds. Every tenth serration is shorter than the others, so that it can be easily identified. By measuring with a suitable scale the distance travelled by the paper between each tenth serration, the exact speed in miles per hour can be read off at once.

The registration on the chart of the locality of the test train is also very necessary. This is effected by means of an electric push connected with another pen. An operator takes up a position at a window, and manipulates the push according to a prearranged code. Thus, one push, which records one tick of the pen on the paper, signifies a quarter-mile post; two pushes, a mile post; three, a station; and four, a tunnel. Again, the working of the locomotive itself is recorded back to the dynamometer car by a similar push in electrical contact with another pen, this push, of course, being operated by an official on the footplate.

Testing the Work done by Locomotives. Another apparatus, known as an *integrator*, registers the work done by the locomotive in foot-pounds. By dividing the foot-pounds of work performed per minute by 33,000 (33,000 foot-pounds per minute are equivalent to one-horse power), the horse-power given out by the locomotive is at once obtained.

Dynamometer cars are also used for testing the efficiency of brakes. An electrical apparatus is connected up with the last or any coach of the train, and records the exact interval of time that elapses between the application of the brake and its taking effect on the wheels of the vehicle in question. Lastly, some dynamometer cars are equipped with an apparatus whereby the running stability of a coach is ascertained. In the coach to be tested is placed an instrument which may be described as a cast-iron spherical shell containing a cast-iron ball. Rubber tubes connect the shell with an extremely sensitive diaphragm in the dynamometer car, when every movement of the coach, as recorded by the oscillation of the ball within the sphere, is reflected by the impressions of a pen attached to the diaphragm.

Locomotive Stationary Testing Plant. However, even with the employment of a dynamometer car, the practical carrying out of a locomotive test under actual working conditions is beset with difficulties of various kinds, especially the practical impossibility of securing similar conditions on any two occasions. In order to obviate these disadvantages, a very elaborate and costly plant has been devised for testing locomotives in the shop. Very few specimens of this plant are in use, and the Great Western is as yet the only British railway to possess one. The latter is located at the Swindon works, where the employees have nicknamed it the "Home Trainer," in allusion to its functions being cast in the same lines as those of the machine of the name on which professional cyclists used to practise. The locomotive is run upon the machine, where its driving wheels rest upon rollers of about 4 ft. in diameter, which the rotation of the wheels causes to revolve, instead of propelling the engine. The axles upon which these rollers are mounted run in bearings which are capable of adjustment longitudinally, to suit the different wheel bases of the various classes of locomotives; and the smoke cowl, into which the funnel is inserted, is likewise adjustable. At one end of the machine is a traction dynamometer for measuring the drawbar pull, to which the engine is connected, while the load is put upon the locomotives by means of brakes, which are applied to pulleys upon the axles of the rollers. A locomotive is tested *minus* its tender, but the plant comprises a kind of dummy tender, over the traction dynamometer, from which the locomotive is fired, while the feed pipes are coupled up to a system of water supply, fitted with measuring apparatus.

Placed on the machine, a locomotive may be run at a constant load and speed for as long or short a time as may be desired. By measuring the speed, which can be ascertained by counting the revolutions of the wheels, and the pull exerted at the drawbar, the power given out by the locomotive can be determined at once. The measurement of coal, water, oil, and so on, is an easy matter; and, as a completely equipped laboratory forms part of the outfit, all manner of practical and exhaustive tests can be applied at the same time to a locomotive submitted for trial. On the Swindon machine, engines have been run at a speed of 70 miles per hour. Nothing of the energy which a locomotive exerts in propelling the road backwards, so to speak, is wasted, as the rollers are connected by driving bands to the shafting of an air-compressing installation.

Liquid Fuel for Locomotives. From the year 1886 until a few years ago, the Great Eastern Railway had a good many locomotives which burned a liquid fuel [91], composed of the waste tar from the compressed oil-gas utilised for lighting the coaching stock, on a system introduced by Mr. James Holden, the late locomotive superintendent of the company. The apparatus proved most successful, but, owing to the enormous increase in the demand for oil which has taken place of late years, leading to greatly enhanced prices for that commodity, the application of liquid fuel for steam boilers has ceased to progress on British railways, and has been discontinued on the Great Eastern itself. During the coal strike in 1912, several companies, but not including the Great Eastern, equipped a number of engines to burn liquid fuel while the strike lasted. The question of internal-combustion engines, employing oil, for railway purposes is quite another matter. It yet remains to be proved whether this machine can be made a practicable commercial success.

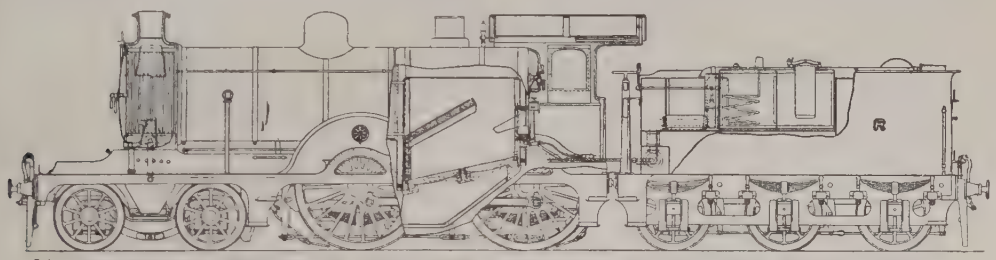
Necessity for a Legal Establishment. As railway companies owe their existence to, and conduct the whole of their business under, the provisions of several Acts of Parliament, it stands

to reason that they are bound down at every turn by legal restrictions and obligations, any transgression of which renders them liable to suffer pains and penalties. Accordingly, they have constantly to invoke legal assistance to define their rights and protect their interests. Most railway companies have special legal departments of their own, which conduct operations from headquarters. The directors appoint a duly qualified legal practitioner of high standing in the profession to take charge of the department, and provide him with a staff of duly qualified assistants, a managing clerk, and as many ordinary clerks and messengers as may be required. The salaried legal staff, of course, resign their general practices, and devote themselves entirely to the company's interests.

The smaller railway companies employ outside firms of solicitors, and at least one great English company does likewise.

The legal branch of a railway company is divided into departments. First, there is the department for Parliamentary work, which carries through Parliament the Bills promoted by the company for new lines and works

Conveyancing and Common Law. Secondly, there is the conveyancing department.



91. LONGITUDINAL SECTION OF LIQUID FUEL LOCOMOTIVE ON THE GREAT EASTERN RAILWAY

An enormous number of deeds pass through the hands of this office, which examines all titles with the greatest care. The number of title deeds, and the like, possessed by any railway company is so great that the general offices are equipped with a fireproof muniment-room for their safe custody.

Thirdly, there is the common law, or "writ and process" department, which covers wide ground. It deals with innumerable trifling matters in connection with claims, outstanding accounts, demurrage, rates and taxes, damage to luggage, animals, and crops; prosecutes fraudulent travellers, luggage thieves, and trespassers; defends actions brought against the company in connection with personal injuries to passengers; deals with cases of injuries to servants under the "Workmen's Compensation Act" of 1897; and is represented in the highest Courts, contesting some such celebrated suit as that of the Taff Vale Railway Company *versus* the Amalgamated Society of Railway Servants.

Qualifications of a Railway Solicitor. The ideal railway solicitor is essentially a railway officer possessing an intimate knowledge of the policy and aims of his company. He must be an experienced conveyancer, for enormous landed interests are entrusted to his keeping, and he must be thoroughly acquainted with Parliamentary procedure, together with procedure in the various courts of law and in arbitration cases.

The chief solicitor or his qualified assistants are at all times accessible to officers of every department who may wish advice in relation to their duties, while in all legal questions that crop up in the department the solicitor has to acknowledge the zealous assistance of officers of other departments.

The Railway Police Staff. Every railway company has its own detective and police staff, the uniformed members of which, as a rule, are far from being merely ornamental accessories of the company's service for the purpose of frightening evil-doers and possessing no power to act summarily in the event of detecting an offender. Under their Acts of Incorporation the railway companies were empowered to swear in so many policemen for each station, and some companies—the Great Northern, for example—have obtained later powers which sanction them to swear in as many of their staff as they think fit. The "sworn" men can arrest any person not only on the company's premises, but within 300 yards of the same.

The Railway "Scotland Yard." The officers of a railway company's detective and police department include a chief superintendent, a chief clerk, and a chief detective inspector, while the staff is composed of detective inspectors, detective sergeants, and uniformed constables. The companies favour recruiting for the department from *inside* the service. It is essential that even the constables should have some experience of the internal working of a railway, inasmuch as the general work of a railway constable differs considerably from that of his civil contemporary, for the former must always be a bit of a detective as well. As to railway detectives, an authority on railway management has laid it down that "a civil detective is of little use in a similar position on the line until he has acquired considerable experience of railway working." The majority of the men composing the "force," therefore, have been originally in the company's service in some other capacity, while the remainder may have been either selected candidates from the Metropolitan, City, or local police, or ordinary private individuals who applied for this kind of employment and were accepted as suitable.

The duties of railway detectives embrace a wide scope. There is the "shadowing" of persons suspected of making bogus claims on the company for personal injuries and loss of luggage. A most interesting volume could be compiled setting forth the cunning frauds which have been perpetrated, and attempted to be perpetrated, on railway companies on those grounds; then the most barefaced spurious claims for loss of luggage are constantly being detected, as, for example, the case of a woman whose alleged lost boxes were discovered to be held by her landlady for unpaid rent. The breaking up of thieving conspiracies hatched by the companies' servants themselves,

and the tracking down of well-dressed rascals who frequent the terminal stations for the purpose of snatching jewel-cases, dressing-bags, and other small articles which passengers have left unguarded in the carriages, keep the detective staff busily employed; but, when all is said and done, the detection of ticket frauds forms by far the larger proportion of their duties. Minor offences perpetrated against railway companies are stone-throwing at trains, trespass, and the malicious mutilation of carriage cushions, window straps and blinds. In all cases of loss or pilferage of luggage, parcels, or goods, the matter is at once referred to the railway police department, which is always in close touch with the civil police. Railway detectives are not, however, privileged to inspect prisoners awaiting trial. Therefore, the chiefs of the departments have a system of exchanging information in regard to the history of suspected persons in custody and of sending their own men to attend trials.

Free Luggage Allowance and Some Anomalies. A railway company is bound to carry free with each passenger his personal luggage to an amount fixed by the Acts of Incorporation of the several railway companies, according to the class of carriage in which the passenger travels. This amount varies in different Acts, but, in practice, the railway companies carry free 150 lb., 120 lb., and 100 lb. for first, second, and third class passengers respectively, and the company's liability with respect to passengers' luggage is the same as that with respect to goods entrusted to it for conveyance, so long as the passengers' luggage is under the charge of the company. If, however, the passenger takes the luggage under his own control, the company's liability is diminished, and arises only where negligence is shown on the part of its servants. The question of what constitutes *personal luggage* has been the subject of many judicial decisions; but, broadly speaking, personal luggage may be defined as consisting of such articles as the passenger requires for his own or personal convenience upon or in connection with his journey. Personal luggage does not include merchandise and materials, such as travellers' samples intended for trade purposes; neither are perambulators, sewing machines, bicycles, bath-chairs, children's mailcarts, hawkers' handcarts, harps, and street pianos admitted to be personal uggage. All this, of course, is fair enough, but it is not easy to see why certain small articles in every-day use, such as typewriting machines and phonographs, should be compelled to pay parcels rates.

The charges for excess luggage are not by any means strictly enforced by British railway companies taken as a whole; and at few stations is it a rule to weigh luggage before it is labelled.

The Baggage-checking Problem. Strictures are often passed upon British railway companies for their failure to adopt the American and Continental system of the registration of passengers' luggage, meaning that a passenger receives a voucher for his luggage at the departure stations and cannot claim any luggage at his destination station unless he produces that voucher. The registration system has much to recommend it on the score of being a prevention against the loss of luggage by theft or by passengers' mistakenly claiming what is not theirs, but it is wrong to suppose that its non-existence in this country is due to any lack of enterprise on the part of the railway companies. The truth is that the British railway traveller will have none of it, for he prefers running the risk of losing his luggage to incurring the slight delay which the system imposes upon him. In the past, the registration system was given a fair trial by several companies, who abandoned it only on the representations of the passengers themselves.

Luggage in Advance. Again, American visitors regard it as a backward state of affairs that the collection and delivery of passengers' luggage does not find widespread favour in this country. This, too, is due to the idiosyncrasies of British travellers, who prefer that their luggage should accompany them wherever they go, and have little faith in its being delivered by the company in time for their purposes. However, all companies now furnish facilities for the conveyance of passengers' personal luggage in advance—that is, collecting at hotel or residence in the principal towns, and forwarding in advance of the owner's journey, and delivery at hotel or residence in the town of destination, at a uniform charge of one shilling per package prepaid. Further, the luggage brought by passengers to any of the stations owned by some companies can be forwarded and delivered within the free cartage boundary at the owner's residence or hotel in the principal towns served by the despatching and also other railways, the charge being 6d. per package.

Lost Property and Left Luggage. The system of dealing with lost property and "left luggage" in a company's cloak-room is, as a rule, the charge of one special department as regards control of staff and general working, although the two transactions are conducted in distinct offices. The companies' servants are not allowed to take charge of luggage or other articles left at the station for the convenience of passengers.

The system observed in a cloak-room is to stack the articles in lots of "singles" (which are generally placed in racks), twos, threes, fours, and so on. This renders the work of identification easier when a traveller claims his property.

All unclaimed or lost luggage and other property found in the carriages at or on the platforms of the stations, or upon the line, must be immediately delivered to the person in charge of the station at or nearest to the place where the article has been found. At the expiration of three days all unclaimed or lost property is sent to the head-quarters of the company, where it is described and registered, and a copy of the register is sent to the Railway Clearing House daily. The Clearing House, in turn, furnishes the information to the different stations, and anything found on hand at a station which answers to the description of an article lost is sent up to the Clearing House for identification.

General Triviality of Unclaimed Articles. The extraordinary conglomeration of articles that find their way into the lost property office and are never claimed has inspired many writers with material for articles on the freaks of human forgetfulness. The machinery employed for tracing the rightful owners has now, however, attained such a pitch of perfection that the companies are burdened with a far less number of articles than formerly, while the articles themselves are mainly of a most humdrum and worthless description. No matter how small or worthless an article, it has a label attached, on which is inscribed the registered number that gives the clue to when, where, and in what circumstances it was found.

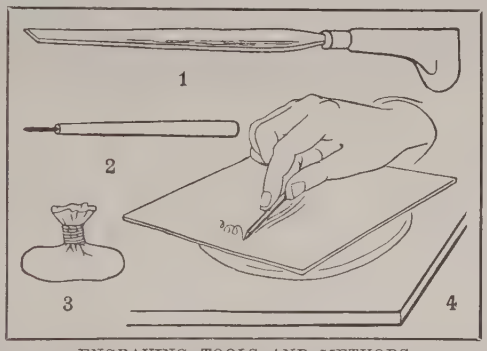
H. G. ARCHER

Copper-plate Etching and Dry-point. Etching in Tones. Line Engraving and its Masters., Prints in Colour. Engraving in Mezzotint and Wood.

THE ART OF THE ENGRAVER

An etching is a print taken by the method known as "copper-plate printing" direct from a metal plate on which lines have been bitten by an acid or other mordant. The plate may be of any metal; but iron, steel, zinc or copper have generally been used by artists; and the latter so greatly exceeds the others in suitability that it is almost invariably chosen. Zinc, however, has certain qualities of its own, producing a strong, rich line which is excellent for broad effects. Its treatment in no way differs from that required by copper, and the description of the process which follows applies to both metals.

Preparing the Plate. The plate used should be of good and even quality and its upper surface given a fine polish—circular. Such plates can be purchased ready for use. The polished surface must be overlaid with a ground, composed, as a rule, of beeswax, asphaltum, Burgundy pitch, and gum-mastic in varying proportions; but equal parts of each may be taken as a good formula for general use. The ground may be applied: (1) hot, by means of a dabber; (2) cold, as a paste dissolved in oil of lavender, by means of a roller; (3) as a solution in chloroform poured over the plate. The dabber [3] is made of horsehair, enclosed in cotton-wool, with an outside covering of silk or kid; and it is advisable to keep the stock of ground in a silk wrapper to prevent grit from getting into it. The grounded plate should next be smoked to a perfectly even blackness, by being clamped in a hand vice and moved to and fro over the flame of a bundle of wax tapers.



ENGRAVING TOOLS AND METHODS

1. Burin 2. Etching needle 3. Dabber for laying etching ground 4. Engraving on metal

The subject of an etching is drawn in line alone, the tool used being of steel, and called a needle [2]. This usually has a fine point and need not be otherwise, for though some etchers have employed a blunt tool for making broad lines, a better result is obtained by relying on the action of the acid for this purpose. The drawing may be made direct on the ground, in fine lines of uniform thickness, with pressure just sufficient to penetrate the ground but not to cut the copper; or, if desired, it may be transferred, either from a lead-pencil sketch made on thin paper, damped, laid upon the ground, and then passed through the press with a little less than ordinary printing pressure; or, again, it may be scratched upon gelatine with a needle, red chalk or some other pigment rubbed into the lines, and the transfer made in the press, as above, or by rubbing the back of the gelatine with a burnisher. In this case the gelatine should not be damped. When the drawing is finished, the back of the plate must be varnished with Brunswick black, to protect it against the action of the acid.

The Etching Bath. The drawing having been thus put upon the plate, the next step is that of subjecting it to the action of an acid bath which performs the function of etching—or eating out in the copper—the lines drawn with the needle. It need scarcely be pointed out that on the success of this delicate operation depends the whole merit of the final result, no matter how good may have been the original design. The bath is of porcelain, sufficiently large to enable the plate to lie conveniently within it, and shallow enough for the upper surface of the copper to be easily accessible. Various liquids—mordants—are used for biting-in at the discretion of the artist, who may, however, be advised to confine his attention at first to one only of the following, in order that he may become thoroughly well acquainted with its qualities and arrange the successive stages of the operation with certainty.

(1) *Nitric Bath.* Nitric acid, of specific gravity 1·42, and water in proportions varying from equal parts of each to ⅛ of acid and ⅞ of water, for copper. For zinc or steel much less acid should be used. Nitrous may be substituted for nitric acid.

(2) *Dutch Bath.* Hydrochloric acid, 10 parts; chlorate of potash, 2 parts; water, 88 parts.

(3) *Perchloride of Iron Bath.* A 40° Beaumé solution of perchloride of iron in water.

The plate is now immersed in the bath, and in the course of a few minutes the bright lines of the drawing will be seen to cloud over with minute bubbles of gas, produced by the action of the acid upon the metal. If the plate be removed from the bath, and the ground cleaned away with turpentine, it will be seen that every line drawn with the needle has been faintly eaten into the plate. If a proof be taken at this stage, the whole drawing will appear in fine lines such as are required for the lightest portion only of the print. Those portions which are destined to remain in this state must be covered again with ground. Stopping out, as this is called, is effected by a careful use of the dabber, leaving exposed all those parts which require strengthening. The plate is immersed again in the acid, and the whole operation repeated as often as necessary, until the proof shows a gradation, as nearly as possible perfect, from lines almost as fine as the needle-point itself to the deep

blackness which gives an etching its peculiar richness of effect. In the course of this proceeding it may be found that the whole design is too light.

Re-biting and Retouching. To darken the design "re-biting" is necessary. The dabber cannot conveniently be used, as it is difficult with it to keep the ground out of the already bitten lines. The difficulty is overcome in the following manner. Some ground is laid thinly and evenly on a piece of plate glass, and a roller alternately passed over this and over the plate, until the latter bears a sufficient ground. This should be done with the plates cold, until the operation is completed, when the oil of lavender can be driven off the copper by a gentle application of heat until the plate shines and the ground becomes hard. In carrying out this operation, the nature of the line made on the copper by the mordant must be borne in mind. This is not V-shaped, but, in section, somewhat wider at the base than on the surface of the plate, the edges being undercut to some extent by the acid. Advantage may be taken of this quality when the lines are over-bitten and print too dark; for, with a burnisher used with oil, their edges may be squeezed together and so made to hold less ink and print lighter. Additional work may, at any stage, be put on the plate with the needle, after re-grounding, and a local effect can be produced by applying the acid with a feather instead of placing the whole plate in the bath.

5. FROM A LINE ENGRAVING BY B. P. GIBBON, AFTER A. COOPER, R.A. (Working proof from unfinished plate)

Ink Distribution. The plate should now be ready for printing, which is done in a copper-plate printing-press, exerting such pressure as to drive the paper into every depression in the copper, and extract the ink therefrom. The ink used is made from any pigment with sufficient body, ground rather stiffly with burnt linseed oil; umbers or ochres being preferred for colour, and Frankfort black, heavy French black, or a lighter black, made from the smoke of burning paraffin oil, for the blacks. The two former are used for giving "body" to the ink, and the latter for blending to obtain special qualities of printing. A great deal depends on the printing of an etching. If the plate is cleaned as bright as possible, by means of the palm of the hand charged with ink and whiting, only the bare lines show, as in a visiting-card. But it is perfectly legitimate and very valuable to arrange the ink on the plate in such a manner as to get much richer effects. In such a case the ink is again worked with the palm of the hand, but with a gentler pressure so as to leave more of it on the plate outside the lines.

A further effect may be obtained by *retroussage*, the dragging of the ink into desired directions with a piece of soft muslin, which is lightly drawn over the heated plate along the lines, following the hand and bringing a portion of the ink over the edges of the lines. This process softens them and makes them print darker than would otherwise happen. By careful arrangement of the ink in these ways, a considerable amount of tone may be produced, but the process has to be repeated, necessarily, for each print. The plate must be kept warm over a "heater" in order to soften the ink, which is first applied thickly with a dabber; the surplus ink is then removed with a pad, and the final arrangement of it given with the palm of the hand as just stated. The paper should be of good quality—old hand-made rag paper is the best—and both soft and tough. It is used damp. At every stage of etching, the temperature must be taken into account. The student should study carefully the etchings of Rembrandt, Vandyck, Hollar, Méryon [7], Whistler (the "Thames Set" in particular), and Sir Francis Seymour Haden, P.R.E.

6. WINDSOR FROM ETON (From an aquatint by Paul Sandby, 1777)

In the soft-ground etching process, ordinary etching ground is used, mixed with half its weight of lard or tallow. The ground is laid and smoked, as already described. When cold, a sheet of thin paper is strained over it, and upon this the drawing is made with a lead-pencil, which causes the ground to adhere to the paper in a broken line, depending upon the grain of the paper, the hardness of the pencil, and the pressure used. The plate is then bitten and printed in the same manner as an ordinary etching, the result being a singularly faithful reproduction of a pencil line. Some good examples of this method can be seen in

A MEZZOTINT OF A HUNDRED YEARS AGO

THE GOLFERS—ENGRAVED BY VALENTINE GREEN FROM A PAINTING BY FRANCIS ABBOTT

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the work of Samuel Prout, but, at the present time, it has almost ceased to be practised.

Dry-point. A form of engraving which is usually classed with etching is produced by ploughing up the copper with a steel or diamond point in such a manner as to leave the upturned metal in a ragged edge or "burr" on the side of a furrow. For this purpose the tool is sharpened to an obtuse angle. No acid is used, the burr holding most of the ink which gives the printing quality to the plate; if the latter were removed, the line would print sharp and clean. Dry-point is sometimes used alone, but more often as a means of finishing an ordinary etching, it being capable of an effect of great richness of black. The plate worked in this manner is only capable of comparatively few impressions, as the pressure of printing soon flattens out and destroys the burr.

Etching Limited to Pure Line. In all the processes of etching it should be remembered by the beginner that he is dealing with pure line, and that, within this limit, the art registers the precise work of the artist. In a reproduction of a picture the aim should be to express in line the intention of the painter, and not to imitate the texture of paint. In the selection of a subject, one lending itself to a bold or graceful arrangement of line rather than of mass, or tone, will always be more satisfactory, and the merit of an etching lies more often in what is omitted, but still suggested, rather than in an extreme of finish. If the right hint is given by the etcher, the eye of the beholder cannot fail to fill in the scheme offered to him with absolute certainty and rare pleasure. The mistake must never be made of confusing an etching with a pen-drawing.

7. LA POMPE NOTRE DAME, 1852
(From an etching by C. Méryon)

Aquatint Etching. This is a method of etching which resembles that already described, so far as it is the result of biting-in a drawing upon copper with acid, and when once the plate is prepared, it exactly resembles it in the process of printing. But the essential difference between this class of print and etchings lies in the fact that in pure aquatint there are no lines. Everything is expressed in tones, as in a wash drawing, of which, indeed, it may be considered the engraved equivalent, as etching is that of pen drawing. This being so, there is no use for needle or graver. The biting-in is done by washes of acid applied with a brush, on a ground having certain necessary characteristics. And the preparation of this ground is, therefore, the first thing to be considered.

The principle underlying the various ways of obtaining an aquatint ground will easily be understood when it is remembered that the smooth surface of an unused plate will not hold ink for printing. It must be roughened in some way. To begin with, therefore, we require, for the purpose of painting acid on the plate, an even printing surface all over it. This is obtained by breaking up the surface into minute dots or reticulations, and can be effected by several methods of laying a preliminary ground, followed by acid biting.

Grounding the Plate. In one case, an ordinary etching ground is first laid upon the plate, which is then heated till the ground becomes soft. Upon this finely powdered salt is next sprinkled evenly. The salt sinks through the soft ground, until it reaches the copper. The ground is then allowed to become cold and hard again, when the salt can be dissolved out with water, leaving the ground pitted minutely wherever it rested. If the plate is now bitten in the acid bath, each of these pittings will produce a black dot. Another method, conveniently known as sand-ground aquatint, is to cover the hard ground with sand, or, better, with emery paper, and pass the plate two or three times through a printing press.

But more convenient than these are the processes known as the "resinous dust ground," and the "spirit ground." In the former, finely powdered resin or asphaltum is placed in a box, which is then shaken rapidly or revolved until a smother of the dust is produced inside. The plate is then inserted at the bottom of the box—and allowed to remain until the dust has settled in an even layer on its upper surface. It is carefully withdrawn, and heated gently, but not enough to melt the dust, a proportion of which will be found to adhere to the plate. The superfluous dust is blown away, and the plate, if bitten, will show a covering of infinitesimal white dots where the particles of resin or asphaltum adhering to it have protected its surface against the action of the acid. This method gives good results, but requires careful manipulation and a specially-made box, with an aperture and door for the insertion of the plate.

The most convenient of all ways of making an aquatint ground is by taking advantage of a curious property of resin. This is dissolved in rectified spirit, and flooded evenly over the plate. As it dries, the resin held in solution is again deposited, and contracts into a series of reticulations, each of which, if bitten, will be represented by a fine line where the acid has penetrated the "crackle" of the resin. The granulations produced will become coarser as the proportion of resin used is increased.

The Aquatint Picture and its Limits. In the making of the picture the high lights are first stopped out with Brunswick black. Acid, as already stated, is applied with a brush, each tint being similarly protected as finished, and the whole completed by successive steps in this manner, leaving the deepest shadows to the last. The method of printing is identical with that of an etching. Pure aquatint, as thus described, is by no means capable of a wide range of expression, although, for certain effects of landscape, it has unrivalled qualities. But its flatness of tone limits it to a considerable extent, and many artists have reinforced this by using a preliminary basis of strongly etched lines, put upon the plate before the

aquatint ground was laid. The history of the art begins with Jean Baptiste Leprince about 1750, although earlier suggestions of it are to be found. It was introduced into this country by the Hon. Charles Greville, who communicated it to Paul Sandby, R.A. This artist made the first English aquatint, in 1774, and his work [6], together with that of William Daniell, R.A., J. C. Stadler, R. and D. Havell, and F. C. Lewis, may usefully be referred to by the student. An aquatint plate, it may be noted, has good printing powers, and is capable of producing a large number of impressions without serious deterioration.

Line Engraving. The old and beautiful art of line engraving is now almost entirely abandoned; but its revival always remains possible. The technique of it is quite simple, but it requires a patient skill only attainable by long practice. It is to be remarked, in the first place, that the term "line engraving" is used to denote only engraving upon a metal plate, made with a special instrument—the burin [1]—which may be described as a short steel tool, curved upwards towards the point, square in section, but grooved on each face, and fitted with a knob handle suitable for holding within the palm of the hand. In the ordinary meaning of the words "line engraving," they might be applied to etching, dry point, or woodcuts; but the custom of ages sanctions the above limitation, which is universally accepted.

All the old engravings were made upon plates of copper until the early part of the nineteenth century, when steel was largely substituted for the softer metal, the term "steel engraving" thus coming into vulgar use almost as a synonym for that forming the title of this section. In pure line engraving no tool other than the burin was used. The subject was first lightly sketched upon the plate, and then gradually finished, the practice of most engravers having been to work from light to dark, gradually filling in the shading as the task progressed [5]. The burin was held in the palm of the hand, guided by the finger and thumb, and driven forward against a pad with considerable pressure, cutting a line almost free from burr [4]. But many engravers made use of the process of etching as a convenient means of getting the outlines of their subjects upon the plate, biting-in lightly, and reworking the lines with the burin.

How the Masters of Line Used its Limitations. At a very early period in the history of the art the dot makes its appearance as an adjunct to the pure line, and this is most easily made with a burin having its point curved downwards instead of up. The old masters kept their work open, using simple shading only to express form. Close cross-hatching—that is, lines crossing and re-crossing each other closely at varying angles—was a development due to attempts at realising the tone, and light and shade, of a painting or wash drawing. In this later work, the dot is used to strengthen, or as a substitute for the cross-hatching, instead of being simply a device to secure a softer effect than line was capable of giving.

The great characteristic of burin work is that it produces only a formal line or line and dot, as compared with the unfettered freedom of the etching. It will turn only in a curve, and thus imposes severe limitations on the skill of the engraver. The great masters of line, such as Dürer, Lucas Van Leyden, Mantegna, Marc Antonio, and our own William Rogers, were able to use this characteristic to splendid advantage, and the leaders of the Dutch and French schools—as, for example, Cornelius Visscher, Nanteuil, and the Drevets—while losing much of the intrinsic value of line, quite compensated therefor by the superb modelling and light and shade with which they invested their portraits. After the close of the sixteenth century line engraving was chiefly devoted to the reproduction of paintings; and the student of this class of work should not rest content until he has made himself acquainted with the admirable engravings which were produced in England by the artists associated with J. M. W. Turner, absolutely the finest landscape engraving the world has ever seen. It was usual to take proofs of the plates in various stages of completion. An interesting series of these can be referred to in the collection of prints and drawings in the Victoria and Albert Museum.

Stipple Engraving. This was a method much used in the second half of the eighteenth century. In it the whole of the picture is represented by dots, carefully placed, at wide or close intervals, to express the modelling and light and shade of the design. These dots were generally made with a needle upon a plate covered with an etching ground, and, when bitten in, deepened and finished with the burin. For this purpose, as already remarked, the burin has a downward point. The roulette, a small wheel with toothed surface, and tools consisting of groups of two or more points, were also employed. A combination of cut line and stipple is also frequently met with. A special form of stipple used particularly for the facsimile reproduction of drawings has received the name of "chalk engraving." It was executed partly with soft ground etching and partly with roulettes and punches. The best examples of stipple engraving—which was frequently printed in red or brown—are to be found in the work of F. Bartolozzi, W. W. Ryland, A. Cardon, G. Vendramini, and L. Schiavonetti.

Colour Prints. Mezzotint, aquatint and stipple, and even line engravings, were frequently printed in colours, the inks used being of the same nature as described above, but with the addition of pigment. Too often the use of colours was merely a device to disguise the wearing of the plate, and although a pleasing effect is produced in the best examples, this defect should always be watched for by the collector. The colours were arranged, as required, on the plate for each separate impression, and it is impossible, as a consequence, to find two prints in colour from the same plate, that exactly correspond in the minutest details.

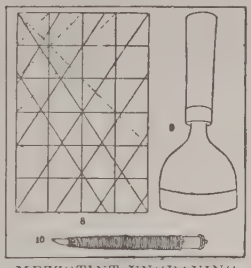
It is fairly easy to detect the extent of handwork which appears on a coloured aquatint or engraving. If it be examined with a lens, the spaces between the engraved dots or lines will appear white in those parts wherein the colour was printed; but where applied by hand, the wash covers everything. Good examples of coloured mezzotint and stipple are to be found in prints by the Wards and J. R. Smith—especially those after Morland; of coloured aquatint by W. Daniell and the Havells; and a good print of pure line engraving, printed entirely in colours, may be referred to—"A Sleeping Venus," by P. W. Tomkins, after Titian.

Engraving in Mezzotint. Of all the varying methods of engraving a metal plate, none is receiving more popular attention nowadays than the peculiarly British art of mezzotint—that is, so far as the productions of bygone engravers are concerned. The number of modern practitioners of the method is, however, small, and although some among them are no whit inferior in skill or taste to their predecessors, the

vagaries of fashion are such that they receive but a paltry measure of support from their contemporaries. Their consolation is that they are undoubtedly working to benefit future generations.

This manner of engraving differs essentially from all others, in that its practice entails the use neither of point of any kind nor of acid. The first essential is the laying of a ground, but this is, in itself, an integral portion of the actual graving to be done. Again, as with an aquatint, the need is to provide the whole surface of the plate with the means of retaining ink, but in this case it is done by roughening the plate with a tool. This is termed *rocking*. The tool used is of steel, somewhat resembling a broad chisel, but with its cutting edge shaped to the segment of a circle [**9**]. The outward face of this tool is regularly grooved to the extent, as a rule, of from 40 to 80 grooves to an inch. The curve is ground, from within, to an edge, which produces a point corresponding to each of the ridges between the grooves. It may be mounted with a short perpendicular handle, and so used, but for the preliminary laying of the ground is better affixed at a right angle to a rocking pole, the opposite end of which is provided with a free slot travelling horizontally between guides fixed to a table.

Rocking and Graving the Plate. The pole should be some 4 ft. long. The plate is held with one hand, while the tool is steadily and regularly rocked with the other, the motion causing it to pass in a straight line from one edge of the plate to the other, making a series of indentations as it goes, and at the same time ploughing up the copper to form a burr. In order to make sure that this roughening is equally distributed, the plate should first be marked out with guide lines for the rocker to follow, and these lines, termed *ways* [**8**], are arranged at various intervals and angles, by means of a scale. About 40 ways give a good ground, and continual re-sharpening of the tool is necessary during the operation. If the plate were now charged with ink and printed, the result would be a rich, velvety black of the finest quality attainable by any process of engraving.



MEZZOTINT ENGRAVING
8. "Ways" of rocking a mezzotint plate 9. Rocking tool 10. Scraper

The picture is produced by scraping away this ground with a broad-bladed, double-edged scraper, terminating in a point [**10**]. It becomes necessary, however, at this stage to bear well in mind what has been done to the plate. Highly magnified, the copper would present, in section, a series not only of elevation but of depressions. The mere cutting away of the burr to the original level of the plate would produce, when printed, only a middle tint, as compared with the full depth of blackness given by the undisturbed ground. To obtain the highest lights, the hollows must be cleared out, otherwise they would hold a considerable quantity of ink and print effectively. Between these two extremes of untouched burr and cleaned out indentations lie the possibilities of obtaining every shade and delicacy of tone in the whole gamut of monochrome.

The Charm of the Mezzotint. It will have been gathered from this description that line does not exist in pure mezzotint. Herein is one of the great difficulties of the art—that of obtaining adequate definition of form. At the same time, the universal softness necessitated by the process constitutes perhaps one of its most alluring charms.

It is usual in practice to transfer the outlines of the picture to be engraved by means of gelatine after the ground is laid. The work then proceeds from dark to light—care being taken to remove the ground gradually—keeping, so to speak, on the safe side until success is assured. The ink used is much the same as that used for an etching or aquatint. It must be thoroughly worked into the whole of the plate, and the superfluous ink then wiped off, particular attention being paid to the clearing of the high-lights.

From the time of its invention, by Ludwig von Siegen (whose first plate was made in August, 1642), until the early part of the nineteenth century, copper alone was used for mezzotint engraving. In 1820, W. Say produced a portrait of Queen Caroline, engraved on steel, and in 1822 the use of this material was perfected by T. Lupton, and for some time it had a considerable vogue. But it was never quite satisfactory. The burr was slighter, the indentations shallower, and it was much more laborious to work, while the dead black ink and white paper used lent themselves only to a limited range of effects, seen at their best in the engravings of David Lucas, after Constable. Moreover, the number of possible impressions was soon found to be little more than could be procured from copper; and since the modern process of steeling plates has been perfected there remains no good reason for the use of steel.

Combinations with Pure Mezzotint. So far we have treated only of pure mezzotint—that is, this method used by itself in the engraving of a plate. But the labour involved therein was so great that the process had hardly attained its full development before other methods began to be used in combination with it, for the purpose not only of saving trouble, but of avoiding the difficulty of defining outlines already alluded to. R. Earlom was one of the first artists to give attention to this endeavour; he frequently employed stipple etching, both as a groundwork and in order to elaborate his detail. In the "Liber Studiorum" (1807-1819) J. M. W. Turner employed generally a combination of etching and mezzotint, using the first process to bite in the strong lines of his composition before handing over the plates to be completed by mezzotint engravers. In the hands of Samuel Cousins, what is called mixed mezzotint was pushed to its utmost limits. He and his contemporaries made use of a heavy roulette as well as of special rocking tools, and also used stipple etching and even aquatint. But these practices do not add to the real artistic merit of an engraving, and it is significant that they were but the prelude to an almost complete decay of the art. The student should study the works of Valentine Green, J. R. Smith, J. and W. Ward, and J. MacArdell.

Steel-facing. The printing powers of etched or mezzotinted copper-plates are very limited. The former class may produce 200 or 300 good impressions, but the latter (and the same applies to drypoint) cannot be relied upon to give more than from 30 to 100 prints of the best quality, owing to the rapid wearing away of the soft metal in the press. An attempt was made, as we have seen, to overcome this difficulty by the substitution of steel for copper, but without success. During the last

two decades science has come to the rescue, and has provided a means whereby the actual engraving having been done upon copper, and full advantage taken of its unrivalled adaptability to this purpose, it may be invested with the durability of steel. The following concise description of the process (by Mr. Frank Short, A.R.A.) is taken from a pamphlet published by the Board of Education, and may be accepted as authoritative :

"Copper-plates when ready for printing are often covered with an exceedingly thin facing of steel (or iron) by suspending them in an iron solution and passing an electric current through it. The copper is covered, almost instantaneously, with a coating of hard, bright iron. From three to twenty minutes may be needed to obtain a sufficient thickness of iron, according to the plate and the current employed. Many solutions containing iron may be used, but the simplest method is to fill the tank with water in each gallon of which is dissolved 1 lb. of sal ammoniac. A large iron or steel plate (the anode) is then placed permanently in it, and attached to the positive pole of a battery (or other electric current), and a small piece of steel (generally an old file) is temporarily suspended opposite to it, attached to the negative pole, until the bath becomes sufficiently full of iron to cause a deposit on a copper-plate when placed in it.

"The plate to be steel-faced is suspended by a strip of copper, soldered temporarily to the back, which serves both as a support to the plate and to complete the circuit of the electric current by contact with a brass rod connected to the negative pole of the battery. The quantity of current passing must be proportionate to the surface of the plate to be steel-faced, and its intensity may vary from 1½ volts to 6 volts. It is essential that the copper should be chemically clean before it is put in the bath, and it is necessary to remove it from the bath every few minutes to wash and gently polish the surface with a paste of fine whiting and water, applied with a flannel, in order to keep the coating clear and bright.

"The steel-facing can be easily removed, when desired, by placing the plate in a mixture of nitric acid and water (1 acid to 7 water), which instantly dissolves the steel, leaving the copper untouched."

A good many wild statements have been made as to the effect of this process, and these need to be corrected. In the first place, it not only does not result in any loss of quality in the print, but it is impossible for the most accomplished expert to decide, from an inspection of proofs, whether they have been taken before or after the plate was steel-faced. Secondly, it does not prolong the life of the plate to the extent that has been claimed. It only makes it possible to produce some few hundred impressions—not thousands—of the best kind.

11. CHRIST BEFORE HEROD
A woodcut by A. Dürer, 1509

Wood Engraving. The old and beautiful art which made use of wood as a material for the printing of the artist's design has almost vanished under the stress of the competition set up by modern photographic processes. But it is so simple, and capable of effects so fine and characteristic, that many hope for its revival.

At the outset we have to indicate an essential difference between the wood-block and that made of metal. In the former the printing is done by the upper surface of the block, exactly as with type. The process is, in fact, *relief printing*, as opposed to the *intaglio printing* of the metal plate, in which the paper is forced by great pressure into hollows excavated in the metal. As a consequence, wood-blocks can be inserted in type without difficulty, and the paper shows no sign of that depression which is known as the plate-mark.

The Dürer Wood-cutting School. There are two methods of using wood for engraving. That employed by the great school of Albert Dürer [11], and for many years afterwards, was executed upon blocks cut plankwise—that is, parallel with the grain. A wood of comparative softness, such as that of the pear-tree, was chosen. The drawing having been made or traced upon the smooth surface, the lines thereof were outlined with a knife, and the superfluous wood cut away with convenient tools, so as to leave the design intact. To this method it has been found convenient to restrict the term "wood-cutting." It is, in all essentials, that employed by the Japanese in their colour prints,

The Bewick Wood-engraving School. At the end of the eighteenth century it was found that boxwood, from its extreme hardness and closeness of grain, was especially suitable for a use to which the term "wood-engraving" is well applied. The blocks were cut not with the grain but across it. The drawing was made upon the block, on a surface prepared for the purpose with Chinese white, and the engraving executed with burins of several sizes. The driving of the burin through the wood produces a white line, the ink being held by those portions of the block untouched by the tool; and this fact was made use of by Bewick and the best of the nineteenth century wood-engravers to produce their effects. Prints by these artists will be seen, on close examination, to consist of a series of white lines or dots, each made with deliberate purpose of expressing drawing. But the burin was also used for facsimile engraving, with a result similar to that of the knife, developing in this respect into a laborious reproduction of the exact lines of the artist's work, as compared with the individual translation of it secured by the white-line method.

The work of Bewick exemplifies the latter; that of Charles Keene in "Punch" is an admirable exposition of the former. EDWARD F. STRANGE

Conditions of Entrance and Service in the British Navy. Seamen and Artificers. Pay and Promotion. The Air Service. The Royal Marines.

THE ROYAL NAVY

THE Royal Navy appeals alike to the patriotic and the adventurous instincts of a boy. The modern tendency towards comfort has shorn the Service of its hardships, except those which are unavoidable in war-time for all active combatants; and the opportunities for advancement make an appeal to a lad who loves the sea, and is willing to work hard at an interesting career for a living wage and a comfortable pension. As the science of war advances, so does the standard of intelligence, and today it is necessary for a Navy man not only to be strong, but also to have brains to direct his energy aright. For the past fifty years the class of sailor has been improving, till now he ranks high among the skilled workers.

So high is the standard of efficiency required of petty officers that the barrier between the officer and man is no longer insurmountable, and a youth who enters the Navy at the age of 16 may well hope to reach a commission before he retires from the Service. Even should the hope fail to materialise, his training will have assured him an excellent prospect of obtaining civil employment ashore.

How to Join the Navy. Application may be made to the station officer of any coast-guard station; to the Royal Marine recruiting staff officer at Belfast, Birmingham, Bristol, Exeter, Glasgow, Liverpool, London, Manchester, Newcastle-on-Tyne, Nottingham, Southampton, or York; to the Commodore of the Royal Naval Barracks at Portsmouth, Devonport, or Chatham, and the naval recruiting officers attached to those ports, and to Oxford and London (East); or at one of the outlying stations which are scattered through the large towns of the British Isles.

The conditions vary from time to time, but it may generally be understood that a youth or man who possesses the qualifications set forth in the table may expect to be admitted as far as his physical requirements go. It should be observed with regard to chest measurement that the examining officer notes particularly the difference between the size of the expanded and contracted chest. This difference should not be less than two inches.

In reply to an application, a form is supplied to the candidate, which he is required to fill up, and if his replies be satisfactory he is provisionally examined. He is then sent to one of the depots for a final medical examination, the trade test (if the candidate desires to enter one of the trade openings), and a simple educational examination. If he fails to pass, his fare is paid home.

The physical standards required of candidates for the Royal Navy are as in the table on this page, but boys of good physique and education are sometimes accepted although slightly below the standard.

While the present war lasts, candidates for the ratings of seaman, stoker, engine-room artificer, and other trades may enter up to the age of 38, or 40 in special cases for service during hostilities only.

Special Service. There are two varieties of service—continuous and special. A Special Service man enters between the ages of 18 and 25, agreeing to serve for the first five years with the Fleet, and for the remaining seven years in the Reserve. After two years' service, however, he may re-engage to complete eight years with the Fleet and four years with the Reserve. He may earn one good-conduct badge at the end of his first three years' service. This bears 7d. a week extra pay. On transfer to the Reserve, with a retainer of 6d. a day, the man is liable to one week's training every year. In case of national emergency he is, of course, obliged to join the Fleet If, after his 12 years' service is complete, the reservist elects to continue to re-enrol for successive periods of five years, he will receive a gratuity of £50 when discharged on completing 20 years' combined service in Fleet and Reserve; but no man will receive the gratuity or be released from liability for active service until he reaches the age of 40 years. A Special Service man, be it observed, has no chance of rising to warrant-officer rank.

Age.	Height without Shoes.	Mean Chest Measurement.
Boys:		
15¾ and under 16	5 ft. 1 in	31½ in.
16 „ „ 16½	5 „ 1½ „	32 „
16½ „ „ 17	5 „ 2 „	32½ in.
17 „ „ 18	5 „ 2½ „	33 „
Seamen, Special Service:		
18 and under 19	5 ft. 3 in.	34 in. (If 5 ft. 5 in. or over, 34½ in.)
19 „ „ 20	5 ft. 3 „	34½ „ (If 5 ft. 5 in. or over, 35 „)
20 „ „ 21	5 „ 3 „	35 „ (If 5 ft. 7 in. or over, 35½ „)
Over 21	5 „ 3 „	35½ „ (If 5 ft. 7 in. or over, 36 „)
Stokers, Continuous or Special Service:		
18 and under 19	5 „ 3 in.	34½ in. (If 5 ft. 5 in. or over, 35 in.)
19 „ „ 20	5 „ 3 „	35 „ (If 5 ft. 5 in. or over, 35½ „)
20 „ „ 21	5 „ 3 „	35½ „ (If 5 ft. 7 in. or over, 36 „)
Over 21	5 „ 3 „	36 „ (If 5 ft. 7 in. or over, 36½ „)
Air Service:		
18 and under 22	5 ft. 3 in.	34½ in.
22 „ „ 23	5 „ 3 „	35 „
23 „ „ 30	5 „ 3 „	35½ „
Domestics:		
16 and under 18	5 ft. 0 in.	32½ in.
Over 18	5 „ 3 „	33½ „
Sick-berth Attendants:		
18 and under 19	5 ft. 4 in.	34 in. (If 5 ft. 6 in. or over, 35 in.)
19 „ „ 20	5 „ 4 „	34½ „ (If 5 ft. 6 in. or over, 35 „)
20 „ „ 22	5 „ 4 „	35 „ (If 5 ft. 6 in. or over, 35½ „)
From 18 to 19, between 5 ft. 5 in.; and 5 ft. 6 in., 34½ in.		
Engine-room Artificers and Electricians:		
21 and under 22	5 ft. 3 in.	34½ in.
22 „ „ 23	5 „ 3 „	35 „
Over 23	5 „ 3 „	35½ „
Armourers, Blacksmiths, Carpenters, Coopers, and Plumbers:		
18 and under 20	5 ft. 3 in.	34 in.
20 „ „ 22	5 „ 3 „	34½ „
22 „ „ 23	5 „ 3 „	35 „
Over 23	5 „ 3 „	35½ „
Ship's Stewards or Writers: No fixed physical standard		

NOTE. These standards are liable to alteration according to the supply of and demand for recruits.

Stokers may enter the Navy in the Special Service class in much the same fashion as seamen. They must complete five years in active service and seven in the Reserve, but can re-engage for eight years

and four in the Reserve. Good-conduct badges can be won in the same way as we have outlined above, and the gratuity on completing 20 years' combined service is the same. Special Service stokers do not, as a rule, rise above the rank of leading stoker, and it is hardly possible to rise even so far in the five years.

After two years' Special Service, men who pass the examination for able seaman or stoker and are strongly recommended may transfer to Continuous Service. They then become eligible for the higher ratings, and their Special Service is reckoned towards the 12 years' engagement. Apart from such a step, it may be said that in the Special Service there is no great prospect of a career. It is, however, an avenue for the men of the Mercantile Marine. They have five years' training, which is most valuable on returning to their civil occupation, and it secures them a retaining fee, which is a useful addition to their wages.

Continuous Service. Men of all ratings, except officers' stewards and cooks, sign on for 12 years, at the end of which time they may re-engage for another 10 years to complete their service for a pension. At the end of 22 years' service they may retire with a pension, or they may be allowed in special cases, if their conduct has been all that could be desired, and if they have progressed satisfactorily, to serve until the age of 50, with an increase to their pension for every year's further service as petty officer. To qualify for the long-service pension they must belong to the Royal Fleet Reserve up to the age of 50.

Men disabled or invalided out of the Service are dealt with fairly generously on a sliding scale by pension or gratuity, according to the nature of their disablement and the circumstances in which they are placed. Men disabled in the execution of their duty are awarded life pensions, irrespective of the length of their services. Furthermore, a grant of £22,000 a year is made by Greenwich Hospital for the assistance of seamen or Marines who have no naval pension or whose pension is small. Pensions to widows, etc., are another feature of the benevolent side of the Service. Another most excellent institution is the Greenwich Hospital School, where 1000 sons of seamen and Marines are educated and maintained free of cost. In addition, 100 boys and 150 girls are supported at various homes.

All men, whether for Continuous or Special Service, receive a free outfit, including a set of bedding. In addition to their pay they receive free rations on a scale greatly improved in recent years. Out of this, by careful management, it is possible to effect "savings," which are credited to the man, and go to buy luxuries.

Boys. A boy must be of good character, must produce a birth certificate, or a declaration made by his parents before a magistrate that he is of the proper age, and (if under 17) the written consent of parent or guardian to his entering the Navy and to his agreeing to serve until he has completed 12 years' Continuous Service from the age of 18. At present a boy may enter, if he wishes, for the duration of the war only. He must be able to read and write a passage from a Standard IV. reading-book, to write a similar passage from dictation, and to have a fair knowledge of the first four rules of arithmetic.

On acceptance, the boy is sent to a harbour training-ship, and is provided with a free outfit of clothes and bedding. After six or twelve months' training on board the harbour-ship the boy is drafted

PAY OF WARRANT OFFICERS, PETTY OFFICERS, AND MEN.

NOTE. During war-time, a Separation Allowance is paid to wives and children.

	Per Day.				
	s.	d.		s.	d.
Chief Gunner, Chief Boatswain or Commissioned Telegraphist ..	10	0	to	12	0
Gunner, Boatswain, or Warrant Telegraphist	6	0	to	9	0
Chief Artificer Engineer ..	11	6	to	13	6
Artificer Engineer	8	6	to	10	6

With Allowances for Special Duties and Qualifications.

	Per Day.				
	s.	d.		s.	d.
Chief Engine-room Artificer ..	7	0	to	7	6
Chief Electrical Artificer ..	7	0	to	7	6
Chief P.O. Mechanic (Air)	7	0	to	9	0
Chief Petty Officer	3	8	to	4	4
Chief Shipwright	5	6	to	6	3
Chief Yeoman of Signals	4	4	to	4	10
Chief P.O. Telegraphist					
Engine-room Artificer	5	6	to	6	6
Mechanician	4	6	to	6	6
Electrical Artificer	5	6	to	6	6
Shipwright	4	6	to	5	3
Chief Stoker	3	10	to	5	10
Petty Officer, Mechanic (Air) ..	6	0			
Petty Officer	3	0	to	3	4
Yeoman of Signals	3	4	to	4	0
Petty Officer Telegraphist					
Stoker Petty Officer	3	2	to	3	6

	s.	d.		s.	d.
Leading Mechanic (Air)	5	0			
Leading Stoker	2	8	to	2	10
Leading Seaman	2	2	to	2	4
Leading Signalman	2	6	to	2	10
Leading Telegraphist					
Air Mechanic	2	0	to	4	0
Able Seaman	1	8	to	1	11
Signalman	1	11	to	2	2
Telegraphist					
Stoker, 1st Class	2	1	to	2	4
,, 2nd Class	1	8			
Ordinary Seaman	1	3			
Ordinary Signalman					
Signal Boy	0	7			
Boy Telegraphist					
Boy, 1st Class	0	7			
,, 2nd Class	0	6			
Boy Artificer	0	6	to	0	9

ROYAL MARINES

	Per Day.			Per Day.	
	s.	d.		s.	d.
Colour-Sergt., R.M.A...	4	2	L.I. ..	3	6
Sergeant, R.M.A. ..	3	7	L.I. ..	2	10
Corporal, R.M.A. ..	2	11	L.I. ..	2	2
Bombardier, R.M.A.	2	8			
Gunner, R.M.A.	1	7	Private, L.I.	1	5

to a sea-going training-ship to gain a knowledge of seamanship and gunnery.

The cruise ended, and the boys having reached the age of 18, they are sent to take their place in the ranks of the Navy as ordinary seamen. No examination is required for this rating, and it is only now that the ambitious young man has a chance of showing what he is worth. He goes to sea in one of His Majesty's warships, and he has the opportunity of learning from his officers and the instructors something practical of gunnery, seamanship, and sufficient engineering practice to pass his examination for able seaman.

Examination for Able Seaman. The examination for able seaman is of the most practical nature imaginable, and consists of the following tests.

A fair knowledge of steering a ship, heaving the lead, rowing, knotting and splicing (hemp and wire rope), and general duties of seamanship; gunnery, torpedo, and field training, which he has learnt

during his novitiate. He must be able to use simple engineers' tools and do ordinary stokehold work, such as sweeping tubes, cleaning boilers, and the like. He must also have a knowledge of bunker-work, firing, and watchkeeping, all of which he will have learnt during his 30 days' course on board ship, during which time he is attached to the engine-room staff and is under the orders of the engineer. Furthermore, he must be able to make and read slowly a signal in semaphore, and understand the use of the flags used in flag-signalling.

As able seaman he will turn his mind to gunnery, and will receive instruction in gun-laying, sight-setting, and so on, from the gunnery lieutenant and the gunner, and in torpedo work, so as to gain the badges of seaman gun-layer, or seaman torpedo-man, or turret gun-layer, etc., each distinction earning him a badge, and each badge carrying with it a small increase of pay, varying according to the qualification.

He will bear in mind also the good-conduct badge which he will be permitted to wear after three years' service as seaman, with a "very good" character from his captain. These badges, awarded at the end of three, eight, and thirteen years' service, carry with them extra pay at the rate of 1d. per day each.

Leading Seaman. Leading seaman is the next step in the sailor's career, which means that he is a good helmsman and leadsman, able to assist in sailmaking and repairing; a practical rigger. He must have a thorough knowledge of the practical side of gunnery; he must be able to make and read semaphore signals, and he must know the use and colours of such flags and pennants as will enable him to look out a signal in the boat's signal-book. His examination is carried out in a sea-going ship, and qualifies him for promotion to second-class petty officer.

Petty Officer. As petty officer the man must, to a certain extent, remodel his existence. He is now in authority; he is directly responsible to his superiors that discipline is maintained, and that the men under his charge do their duty efficiently. By this time he will have made up his mind whether he prefers the duties of mere seamanship and the working of a ship, or whether the guns attract him more. In the first case his goal will be that of boatswain, and in the latter he will aspire to the position of gunner.

It is of the highest importance nowadays that men should take the earliest opportunity of qualifying in gunnery and torpedo work, for the war has directed even more attention to these branches of a seaman's education than in normal times, and it may quite easily happen that his promotion will be very seriously retarded by the lack of a certificate.

Ultimately the seaman reaches the rating of chief petty officer or warrant rank (gunner or boatswain), when he drops the bluejacket's characteristic garb for the blue cloth coat and peaked cap, or "fore and aft rig," as the sailors call it.

Chief Petty Officer. Candidates for chief petty officer are not put on the roster until they have five years' service, with a very good character. Then their names are put down for promotion, and in due course they are selected by seniority, tempered by selection, on the reports of service and attainments. Since a warrant officer or a chief petty officer comes into close contact with the officers of the ship, it is most desirable that he should have taken every possible step to improve his education and his manners, in the time of waiting, by the assistance of the instructor and by some private study.

Chief petty officer or warrant officer is the highest position reached by the majority of seamen, but a few still higher posts are available. Chief gunners and chief boatswains nowadays hold what are known as "lower-deck commissions"—that is, they are commissioned officers of warrant rank, who continue to associate with the warrant officers and chief petty officers of their ship. The man for whom this article is written, however, will aspire to climb yet one step higher—to the commissioned rank of lieutenant. For this rank it is essential that his education should be excellent, for he may have to live in the ward-room with college-trained officers, and this point is taken into consideration in selecting men for commissions.

Gunners and boatswains, and petty officers who have passed in seamanship for warrant rank, may be chosen for this distinction if not over the age of 25 years. After qualifying in certain subjects, candidates are given the rank of acting mate, being classed as ward-room officers and receiving 8s. a day pay and 2s. messing allowance. A spell of further instruction follows, and the selected candidate becomes a mate, with the relative rank of sub-lieutenant, being also eligible for further promotion to the grade of commander. Warrant officers under 45 years of age who distinguish themselves by acts of gallantry and daring may be promoted to be full lieutenants.

Promotion in the Navy. To give some idea of the rate of promotion in the Navy, it may be said that in peace-time a smart young man with a fair education might hope, with luck and diligence, to reach the rank of second or first class petty officer by the time he is 24, and to become chief petty officer at 28 or 30 years of age. Warrant rank would come in about the same time. War naturally quickens promotion very greatly for the fit and the fortunate.

It should not be forgotten that for chief petty officers and warrant officers there are many good shore billets in the shape of instructorships at the colleges, at torpedo and gunnery schools, which not only carry with them a handsome increase of pay, but provide a most comfortable home for a man who has, perhaps, tired of the perpetual change of quarters which the exigencies of naval service involve. These go, of course, to men who are favourably reported to headquarters as being energetic, trustworthy, and who, by their application to the theoretical side of their work, have fitted themselves for the posts.

Engine-room Staff. Boys may be entered as boy artificers between the ages of 15 and 16, after passing the usual medical examination and an educational test of ability to read and write. They agree to serve for 12 years' continuous service from the age of 18.

On entry, the boy artificer is placed on the ship's books for training at one of the home ports, and for the first four and a half years is learning his trade as a workman under an instructor; is instructed in steam and general engineering subjects by an engineer instructor, and in general knowledge by a schoolmaster. His duty in life will be the care and repair of engines, as compared with the stoker class, whose business is to drive them. After the 4½ years' course, and a final examination in the subjects studied, he is classed as an engine-room artificer, fifth rate. He goes to sea for about a year, and if he proves efficient he is rated as acting engine-room

artificer, fourth class. It is possible for a practical engineer between 21 and 28 years of age to enter direct if he is able to pass the examination, which is as follows: A knowledge of the first four rules of arithmetic; ability to read and write well enough to record the working of engines and boilers; a general acquaintance with the names, uses of parts of marine engines; ability to run engines and to effect the ordinary repairs of an engine-room. Candidates who hold a Board of Trade engineer's certificate, first or second class, are excused this examination. After one year's service as acting engine-room artificer, fourth class, the man, on obtaining a certificate from the captain that he is capable of taking charge of a watch in the stokehold, and that he is an efficient workman worthy of confirmation in his rank, becomes a fourth-class artificer.

After three years' service above the rank of fifth-class artificer, he passes to third-class artificer; in seven years to second-class artificer, and after 12 years' service, if he engages for another 10 years, to engine-room artificer, first class. Above this lies chief engine-room artificer, second class, for which he must pass an examination in arithmetic up to vulgar and decimal fractions, and show his practical knowledge by being able, for example, to estimate bunker capacity or a cylindrical oil tank's contents. His knowledge of engineering must be wide and practical. He must know the best methods of prevention and cure of ordinary engine and boiler room casualties; must understand the management of boilers generally, and the running and use of valves; have a good knowledge of indicator diagrams and the calculation of horse-power; understand the adjustment of bearings and the fittings of brasses.

Six years in this rating qualify him for chief engine-room artificer, first class. Chief engine-room artificers of 29 years of age are eligible for advancement to warrant rank on passing the examination for artificer engineer, and receive a gratuity of £25. These, again, may pass to chief artificer engineers, from whom, by selection, there are chosen a few engineer lieutenants.

Stokers. The men who tend the boilers are in a far better position today than they were formerly. "Once a stoker, always a stoker" used to be the saying; but now, by good conduct and willingness to work at the theoretical side of his trade, the stoker can rise to be chief petty officer, and even attain warrant rank, though few stokers expect the latter. An able-bodied man of good character and physical development, without previous experience, may enter as second-class stoker. After a period of instruction in his duties and in rifle, pistol, and cutlass drill (for a stoker must know how to fight nowadays), he is promoted to first-class stoker on completing a year's service.

After four years' service comes a short course of instruction, followed by a test examination, and, that being satisfactorily passed, he becomes leading stoker. After serving in this capacity he is eligible for advancement to acting stoker petty officer. It will now be necessary for him to work hard at his education if he wishes to rise further. He must attend a torpedo course to give him a knowledge of the engines and general working of these weapons; and after having served ten years in stoker ratings he may be promoted to chief stoker, which ranks as chief petty officer. The examination is the same as for leading stoker, but in addition he must have a general working knowledge of the parts and uses of engines and boilers. Acting leading stokers who have been selected for special ability are eligible to be rated as mechanicians, rising to warrant mechanician and chief warrant mechanician when they take charge of engines.

Signalmen. Signal boys are selected from the smartest of the second-class boys, or, if vacancies occur, from among the first-class boys. Occasionally they are entered direct from Greenwich School. They are given an elementary signal course, lasting some three months, and are taught the elements side by side with their instruction in seamanship. The work requires keen eyesight and a lively intelligence, for a signalman is one of the most responsible men in the ship.

The next step, that to ordinary signalman, is reached when the boy is over 18. The aspirant by that time must have gained a working knowledge of day and night signals. For this and the higher ratings men are not obliged to qualify in the same fashion as an A.B., but are exercised in gunnery and musketry. For the next rating of signalman is necessary a good working knowledge of day, night, fog, gun, and sound signals as applied to fleets, ships, and boats, as is a proficiency in the use of the Morse code, semaphore, and flash signals.

After a sufficient experience as qualified signalman a man is advanced to leading signalman, when he must be able to undertake the duties of a signal petty officer, and must understand the regulations for prevention of collisons at sea. Good men with experience are then promoted to yeoman of signals. Chief yeoman and signal boatswain are the next steps in the signalman's career, the appointments being made by seniority, tempered always by selection of the best workers and the steadiest men.

Wireless Telegraphy. Like the signal section, this branch is recruited from smart boys of the seaman class who have finished their harbour training. They undergo a special course of instruction, and at 18 are eligible for the rating of ordinary telegraphist. From this they progress according to ability, through grades equivalent to those of the signal branch, up to warrant rank, commissioned warrant rank, and, in exceptional cases, to that of full lieutenant.

Air Service. Candidates for the Royal Naval Air Service must have had experience in the construction or repair of aircraft, the care of petrol engines, motor-driving, cycle-making, or boatbuilding, or as electricians, coppersmiths, or carpenters. They are normally required to enter as mechanics for four years' active service, and four years in the reserve. During the war they may join for the duration of hostilities. Young unmarried men already serving in the Navy may be allowed to transfer to this branch. Experienced artificers entering the Air Service are rated at once as petty officer mechanics.

Airmen may be detailed for any branch of the service, whether seaplane, aeroplane, airship, seaplane ship, or kite work. It by no means follows that every member of the Air Service learns to fly. Only those who appear to have the special qualities needed for successful flight are chosen to be trained as pilots. An airman so selected receives an extra 1s. a day while under instruction, 2s. a day when he gains a second-class flying certificate, and 4s. as soon as he holds one of the first class. The crews of airships are paid 2s. "flying pay" daily while so employed.

Naval Craftsmen. A few boys between 14 and 16 years of age are eligible for service as boy shipwrights. They have to pass the Civil Service examination laid down for dockyard

apprentices, and agree to serve for 12 years after the apprenticeship, and are instructed in the yard until the age of 18, when they go to sea for training if they are found to be fit for the rating of carpenter's crew.

Among the skilled tradesmen entered for service ashore and afloat are the electrician, the carpenter, and the shipwright, the armourer, blacksmith, and the cooper.

Young men of good character between the ages of 18 and 28 who are sufficiently good carpenters to do panelling, dovetailing, and sash-making may join, with the prospect of ultimately rising to petty officer joiner.

Shipwrights. Skilled workmen with a good knowledge of shipbuilding in wood, iron, and steel, and of repairing boats, are admitted between the ages of 21 and 28 as naval shipwrights, with the rating of petty officer. They are eligible for promotion to chief shipwright, and to the warrant rank of carpenter, while specially able and well-educated men may attain commissioned rank as carpenter-lieutenants, with pay at the rate of £237 to £273 a year. Competent naval shipwrights who complete their time for a pension can obtain similar employment in the Government dockyards on quitting the sea.

Coopers who pass a trade examination in making a bucket, also armourers, plumbers, and cooks, with a knowledge of their respective trades, can all join the Navy with the prospect of rising to chief petty officer in due course.

Electrical Artificers. The electrician is another of the skilled tradesmen who are always welcome in the Navy. He must be between the ages of 21 and 28, and must have had five years' practical experience as fitter and turner, or instrument maker. Men are preferred who have some knowledge of electricity or who have gained their experience in electrical shops. The candidate must pass an educational examination equivalent to school Standard VI.; he must know arithmetic up to vulgar and decimal fractions, and be good at dictation and reading. The practical part of the examination consists in relining and readjusting metal bearings, metal turning and screw cutting on a lathe, and repairs to electrical apparatus and instruments.

During his training the electrical artificer enters the torpedo school, and goes through a course of instruction, at the expiration of which he has to pass a further examination in repairing and fitting electric motors and all electrical instruments required in the Service. He must gain a good knowledge of the construction and repair of Whitehead torpedoes, and he must understand the intricacies of electric lighting and wireless telegraphy. After six years' approved service, of which three must have been spent afloat, he is eligible for promotion to chief artificer, second class. The rating of warrant electrician lies at the end of the service after a thorough examination in every branch of the art.

Sick-berth Staff. A limited number of young men between the ages of 18 and 22 may join the Service as sick-berth attendants if they can produce evidence of very good character, and have an elementary education. Selected candidates are accepted on probation, and go through a course of training at Haslar Hospital. They rise from sick-berth attendant through the grades of sick-berth steward, to chief sick-berth steward. There are a few shore berths open at Royal naval hospitals as wardmasters, and in the warrant rank of head wardmaster, but promotion is not rapid; and unless the candidate has a special liking for the work, the position is rather trying.

Writers and Ships' Stewards. These ratings are being filled at present for the term of hostilities only. Candidates must be smart men, of good character, not less than 18 years old. They are examined in spelling, writing, and arithmetic; and, in the case of writers, in typewriting and shorthand also. The latter class are employed in correspondence and keeping accounts on board ship, while the duties of ships' stewards relate to the victualling and clothing of the crew.

The Royal Marines. The Royal Marines are soldiers with sea training and sailors capable of military duty; they are experts in artillery work, yet they can pull a boat as well as any seaman. About two-thirds are serving in detachments in seagoing ships, while the other third are at their various depots, undergoing courses of infantry and artillery training. The advantages of the Service are change of scene and occupation, greater freedom of action than is enjoyed by soldiers, a wider field of training, and better pay. There are two branches—the Royal Marine Light Infantry (the Red Marines) and the Royal Marine Artillery (the Blue Marines).

Entrance Conditions. Young men from 17 to 23 years of age are eligible, provided they can pass the medical test and can read and write, and know the first four rules of arithmetic. On acceptance, they are forwarded to Eastney Barracks, Portsmouth, if for the Royal Marine Artillery, or the Depot, Deal, if for the Royal Marine Light Infantry. Normally the Marine must join for 12 years; but owing to the European war, recruits for the Light Infantry only are specially accepted for three years, or the duration of hostilities, and in that case must be between the ages of 19 and 30. Free kit and bedding are issued to every man.

The infantry recruit, after completing a course of infantry drill, swimming, gymnastics, and musketry, is drafted to one of the three great stations—Chatham, Portsmouth, or Plymouth—which becomes his home ashore, as is Eastney Barracks for the artilleryman.

Work of the Royal Marine. On completion of the above-mentioned instruction, the recruit undergoes a course of field training and heavy-gun drill, and in about 15 months is considered a qualified man. He is then available for sea service, and, as soon as the exigencies of the Service allow, is drafted to one of his Majesty's ships. If his ship be serving in home waters, this period will be from one to two years, but if abroad it will be probably three years before he sees his "home" again, when he will take his leave on full pay, and come back to requalify in shore work. Promotion to the superior ranks is not so rapid as in the Line regiments of the Army, but he may expect to be promoted to corporal within five years, to sergeant in 10 years, and to colour-sergeant in 16 years. There are also a few quartermasters' and warrant officers' positions open by selection and seniority to non-commissioned officers. The educational standards required of the various ranks are the same as those of the Army for an infantryman, promotion being dependent on the passing of these examinations, and also on the sea service completed.

Bandsmen. Marine bandsmen join the service between the ages of 15 and 23. They must be able to read and write, and have some musical knowledge. They are sent for training to the Royal Naval School of Music for instruction, and at the age of 18, or when fully trained, they become available for service. The pay ranges from 4s. 8d. a week for boys to 38s. 9½d. for the highest ranks, with an allowance of 1s. 2d. per week for instruments, and good-conduct pay up to 3s. 6d. per week.

Different Classes of Catalogues. Preparing a Trade List. Export and Special Lists. Retail Catalogues and Departmental Lists.

CATALOGUES AND PRICE LISTS

One of the most important branches of advertising is the preparation and distribution of business catalogues and price lists. No matter whether the firm be a wholesale house, a retail establishment, or a manufacturing concern, if it has a business of any size it must issue a price list for the information of would-be customers, where detailed particulars can be obtained of the goods the firm sell.

The preparation of the catalogue is, however, not such a simple and straightforward matter as it may seem at first sight. Apart altogether from the question of production in an attractive form, it must first of all be clearly decided to whom the catalogue is to appeal, for what particular class of people it is intended.

Different Classes of Catalogues. Catalogues and price lists may be divided into three main classes—(1) those that are intended for the trade—that is, for the use of the retailer; (2) those that are intended for the consumer—the members of the general public; and (3) those that combine something of both characters, and are intended for the trade, but are so prepared that they may be shown by the retailer to his customer. The first class of list is that issued by the manufacturing firms throughout the country, small and great, and by the wholesale houses; the second is issued by the large stores like the Civil Service, Army and Navy, etc., and by the better class of tradesmen, such as grocers in a good way of business; the third are issued by such firms as hardware manufacturers, makers of gas and electric-light fittings, etc., and enable builders, ironmongers, and so on to show a variety of designs to their clients without the necessity of keeping the actual articles in stock. In such cases the client selects his design from the pictures in the catalogue, and pays the price therein printed, the dealer getting a substantial discount off this price from the manufacturer.

It will be realised, with a little thought, that these three classes of catalogues are entirely different propositions, and must be approached in different ways. Then, again, in each class different businesses need entirely different treatment; and whereas an engineering firm in an extensive way of business may need a very large catalogue—large both in the number of pages and in the size of the page—because of the great variety of lines it turns out, and the need for well illustrating many or all of these, the makers of some household commodity, such as an infants' food, or jams and jellies, or a cocoa, may need a comparatively small price list, because the number of lines produced is very limited; the vast turnover is done in one or two articles only.

In the case of a retail price list, too, the size may vary from a twenty or thirty page list issued by a suburban grocer to a great volume of fifteen hundred pages or more, strongly bound in cloth, thumb-indexed, and illustrated with thousands of pictures, like the lists issued by the great stores. Such catalogues are veritable encyclopædias of the articles used by people in everyday life, ranging from clothes, games, furniture, and books to foods, soaps drinks, and medicines.

General Principles to be Followed. In planning out a catalogue, whether it be for the trade or for the consumer, there are a number of general principles that must be taken into consideration. And the first is that the list must be got up as attractively as possible consistent with reasonable expenditure. This statement needs elaborating. It goes without saying that a cheap and nasty price list, badly printed on common paper, with poor blocks and ugly type, is a bad advertisement. But in producing the list it does not follow that all firms are to go to the opposite extreme, and turn out catalogues that are works of art, beautifully printed in choice types on calendered paper, with rich blocks, the whole being splendidly bound in cloth. Such a list would, of course, be an excellent advertisement, but the cost of production may be so great as to increase the selling cost of the goods beyond what is remunerative. Then the list becomes a losing proposition. Some high-class articles on which there is a very large margin of profit may warrant the catalogue that rivals a magazine in appearance, but the style of the list in all cases must depend upon the amount of money that can fairly be devoted to it, and this must be arrived at by the heads of the firm after careful consideration.

Then a list should be as comprehensive as possible, and this for two reasons. In the first place, it should be in actual fact what it professes to be—a list of the things manufactured, dealt in, or supplied by the firm issuing it; and no one going to the list to look for a certain article supplied by the firm should fail to find it there, with all necessary details explicitly set forth.

In the second place, the mere fact that the catalogue is complete, and has other lines besides that for which a customer may consult it, is likely to result in business, for many an article is bought by the consumer, or stocked by the retailer, not because he wanted it definitely in the first place, but because he was attracted to it by seeing it portrayed and reading a description of it. This is why price lists should as far as possible be well and copiously illustrated. Even a common, everyday article like cocoa, jam, or salt may sell, where it would not otherwise do so, because it is nicely packed, and the package makes an attractive show in itself and when reproduced as an illustration.

A third principle to be followed in the preparation of a catalogue is that it should always be clearly and systematically arranged, so that anything that is looked for can be quickly and readily found; and however small the list may be, and however few the lines referred to in it, it is always wise to have an index.

Blocks for Price Lists. As the question of the kind of blocks to be used in a list applies equally whether the list be for the trade or for the consumer, a word or two may be said here on this subject. Where an art paper or an imitation art paper can be used, the blocks should, of course, be

half-tones of as fine a screen as possible. The technicalities of block-making are dealt with in another part of this book. For many articles photographs make better pictures than drawings, as in the case of machinery and clocks, etc., for example; but for things like furs, dresses, hats, and so on, drawings can be made to give a better idea of the article than photographs. Even in the case of machinery it may sometimes be an advantage to have a drawing instead of a photograph, so as to bring out clearly some particular feature of the mechanism.

If the paper has a not very glossy surface, then the screen of the blocks should be coarser, or the blocks will get clogged with ink in the printing, and the pictures will be smudged and muddy. For papers that have no surface, rough papers and common papers, it is better not to risk half-tones, but to use process blocks made from line drawings, or wood-blocks. These, if well done, can be made to give quite a good effect, certainly infinitely better than badly printed half-tones.

The Selling Force of a Catalogue. Many firms when they start to prepare a catalogue overlook the fact that it is, or should be, advertising. They think that so long as their various lines are mentioned and illustrated, all that is necessary has been done. Others go a little further, and see that a thoroughly competent printer takes real pains in producing the work artistically and well. The printing is good, the type is attractive, and the blocks are well made and well reproduced, but from beginning to end the book has no selling force.

Now, the first step in producing an effective price list is to have the right matter. The catalogue is not the same thing as a booklet, and cannot have a long and connected story about the firm and its goods, but, very briefly told in a few words, there should be something said about the various lines, some reason given why the tradesman should stock or the public should buy the article. This need not take up a great deal of room, but in the baldest of trade catalogues it will tell. In fact, it is almost better to have a good selling list printed in second-class style than to have a list first class from the typographical point of view but inferior from the advertising, and therefore the selling, standpoint. Certainly, success depends as much upon the matter as upon the get-up of the list.

Preparing a Trade List. The first thing, then, in preparing a trade price list, as it is in preparing all kinds of catalogues, is to get the matter together. This must be arranged in the proper sequence, the various lines kept together in their classes, and every size and style of package in each line set forth clearly, with its price. Thus if it is an engineering catalogue, and a certain pattern gas-engine is made in three different sizes, each must be referred to, with full particulars as to dimensions, horse-power, size, price, etc. Or if the list is that of a jam and marmalade firm, each size package must be mentioned and priced, one pound, two pound, three pound, seven pound, fourteen pound, etc.; and if these sizes are packed in various styles of receptacles, as in glass and stoneware, then each size in each style must be set out, with its price. Where a commodity is sold in bulk the bulk price must be given; and if goods are sold in cases and the cases are charged for, this, with the price per case, must be stated. The allowance, if any, for returned empties should be clearly mentioned; and where goods of the same class are sold in assorted lots the make-up of the assortment should be set out for the guidance of the buyer. In some instances it is wise to give the weights and measurements of the cases.

There should always be a page of general information, and very often the second cover—that is, the inside of the cover in the front of the list—or the title page is used for this purpose. There should be stated the terms and conditions on which the firm does its business, the various addresses of its branches and depots, its telegraphic address, telephone numbers, codes used, and any Royal and Government appointments it holds.

Illustrations for a Trade List. Having prepared the matter in manuscript, it is necessary to get the illustrations ready. For this purpose the various articles to be portrayed must be photographed. Of course, where they are large and heavy, as in the case of machinery, the photographer must attend the factory and take the pictures there, and every facility should be given him in the way of light, backgrounds, and so on, for the success of the price list from the selling point of view will depend to a certain extent on the pictures of the articles it is bringing to the trader's notice. If, on the other hand, the articles are small, as when they are food packages, boxes of soap, bottles of wine, and so on, it is much better to let the photographer have them at his studio, where he always has greater facilities for taking pictures than any ordinary factory can provide.

As so much depends on the pictures, only a really first-class photographer should be engaged. The pictures need taking only once, and a little extra cost does not amount to much when spread over thirty or forty thousand copies of the catalogue. The photographs, being taken satisfactorily, are not quite ready for the blockmaker. It is here that so many pictures that might be excellent are spoilt, just as the historic ship was spoilt for lack of a ha'p'orth of tar. To get the best results in the blocks for printing it is necessary that the photographs—that is, the prints—should be touched up by an expert retoucher. In many cases—in most cases, in fact—it is best to have the backgrounds painted right out, so as to leave the object standing right out before the observer, with no surrounding objects to distract attention. Special points can be emphasised; and it is astonishing how much a skilful retoucher can paint out or paint in on the print which will appear as part of the photograph when the block is made and printed.

The question of the photographs is very important, and must be treated as a whole, for it is quite possible for each individual picture in a catalogue to be excellent, but for the whole to give an odd and scrappy and disconnected appearance to the book. For example, if a number of boxes are to be portrayed on the different pages, then these should all be photographed at the same angle. The main label must, of course, be the principal feature that stands out, whether it be the top or the side of the box, but the photograph should not be a full front view; a little of the other sides of the box should also show. All the pictures being thus taken at one angle, there is a harmonious feeling that appeals to the person looking through the list, although possibly he may not be conscious of what gives the unity. Nothing can be more incongruous than to have a number of boxes or packages, more or less similar in shape and appearance, printed on the same or opposite pages in a list, some showing a little of the right-hand side,

some a little of the left, some the top, and some the bottom, and so on.

Another point must be mentioned in this connection. If the objects to be photographed are round, as in the case of tins and bottles, then it is important to get all the label into the photograph, so that it can be read easily. Very often a commodity may be packed in receptacles of several sizes; and while one bottle or tin may be so small in diameter that the label goes too far round on either side for the name to come out completely in a photograph, a larger size with a greater diameter to the receptacle may take the label so that the photograph will get it all in clearly. In selecting a picture to illustrate the line, the size bottle or tin that looks best in the photograph should be chosen. This seems a simple matter, but it is astonishing in how many thousands of catalogues it is overlooked or ignored.

Still one more point in connection with pictures illustrating a price list needs a reference, and this is the size of the blocks. It is, of course, always wise to give the pictures as large as possible. Small blocks are apt to look mean, and make the object they illustrate insignificant. But while fairly large blocks should be the rule, it is not wise to make every block as large as space will allow. Some sort of relation must be maintained among the various articles portrayed. Thus while a one-pound tin of coffee and a seven-pound tin cannot be given to scale, yet the seven-pound tin should appear somewhat larger in the list than the one-pound. A one-pound tin appearing in the picture twice as great as the seven-pound tin would make the catalogue ridiculous. On the other hand, the same sort of relation as to the size need not be maintained in regard to entirely different lines appearing in different parts of the book. Common sense should be the great guide, although an examination of some hundreds of price lists does not suggest that it has come much into play in this matter of the relative sizes of blocks.

Size and Shape. Before actually making the blocks we must decide upon the size and shape the catalogue is to be, and this is, of course, guided largely by the amount of matter that has to be got into the list and the nature of the pictures. While for the purpose of showing machinery or other objects as well as possible it is an advantage to have a large page, so as to get the blocks big, it is unwise to have the page so large as to be ungainly. The whole point of a trade catalogue is to keep it in the hands of the dealer; and if the size is too large it is likely to be folded and get pushed out of sight. It is better, therefore, in a general way, to conform to the custom of the trade, and make the list more or less in size and shape like those of other manufacturers in the same line of business. Of course, there are pioneers even in the production of trade lists and catalogues, men who strike out in new shapes and sizes, but, as a rule, in these days the best form has already been arrived at, and there must not be too much striving after novelty.

Another consideration has to do with the printer and papermaker. Paper is manufactured in sheets of certain stock sizes, and these fold up into eights, twelves, and so on, of certain recognised page size. It is always costly, therefore, to depart too much from stock sizes, as the paper has to be folded and cut to considerable waste. Then the number of pages should, if possible, be kept in multiples of sixteen for a large list, of eight for a smaller list, and of four for a still smaller list. If the cover is not being printed on a separate paper, but on the same paper as the body of the list, then it should form a part of one of the sixteens. Thus the list will consist of a four-page cover and twelve, twenty-eight, forty-four, or sixty, etc., pages. If, on the other hand, the cover is on a separate paper, coloured or white, then the body of the list would have sixteen, thirty-two, forty-eight, sixty-four, etc., pages, independent of the cover.

The matter and the pictures that are to go in being ready, the best size of page for the list and the exact number of pages must be decided; and it is always well in this matter to confer with the printer. This matter being settled, a selection of types for the headings, paragraphs, prices, etc., must next be made; and before going on with all the list it is advisable to get a specimen page set up. In actual practice, a type that looks well in the type-book or in another advertisement may not prove so suitable as was supposed; and by having one specimen page set up it is easy to make alterations until something that commends itself as typographically satisfactory is obtained. The list is to be printed in large quanitties, it is to be revised from time to time, but kept in the same form for the sake of continuity, and it is therefore worth while in the beginning to take a little trouble to get it as nearly perfect as possible for the object it is to fulfil.

Filling Blank Pages. It very often happens that after getting all the matter set up and arranged in page form there are one or more pages out of the sixteen that are left with no matter for them. Incredible as it may seem, some manufacturers actually issue their catalogues with these pages empty. Could anything be more futile? Here is an opportunity, at practically no cost at all, to tell the story of the goods, to provide some really good selling talk, to give pictures showing the equipment of the factory, and yet the opportunity is often missed.

The advertising man will take full advantage of such a chance. If the factory is an engineering works, pictures and descriptions of the up-to-date plant should be given; if the factory turns out food products, the cleanliness should be emphasised and illustrated, reproductions being given of any certificates of purity that have been obtained from official and authoritatvie sources. In all cases, extracts in praise of the factory from responsible newspapers and journals, testimonials from well-known customers, and similar recommendations should be reproduced.

The Cover. The question of the cover is one to which some time and thought should be given. If the paper is to be different from and better than that of the body of the list, it is as a general rule an advantage to select a coloured paper. Where, however, half-tone or even line blocks are to appear on this, the colour should be a light one, or the blocks will not show up to advantage. Where a calendered paper is used, if white be selected, this begins to look shabby and old directly it is handled, as every mark of the fingers shows up. No hard-and-fast rule, however, can be laid down; each case must be treated on its merits.

Another question which has to be decided in connection with the cover is whether it is to be printed in one, two, or three colours. Here it may be said that save in exceptional circumstances it is never worth while to go to the expense of three-colour blocks for the cover of a trade catalogue,

attractive as such may be for a list that is being issued to the general public. It is sometimes worth while to print a trade list in two colours, but usually this is an unnecessary expense, as a two-colour effect can always be obtained by using a coloured ink on a coloured paper. Even for trade catalogues the cover design should not be left to the tender mercies of the printer. He will make up a more or less elaborate border or design to fill the page, but it will always smack of the mechanical, being composed of stock ornaments pieced together. For two or three guineas a very good, plain design for a catalogue may be obtained from a competent artist, and this will serve for years. In getting a design that is to last, see that such wording as is likely to be changed from time to time—date, telephone number, and so on—is not part of the design, but can be let into boxes or panels drawn by the artist as part of the general scheme.

Reading the Proofs. Great care must be taken in reading the proofs of a price list, and every figure should be checked in the final proofs just as they go to press, a duplicate being kept with all the corrections in the printer's copy, so that in the event of any mistake the responsibility can be fixed. The advertising manager should see that the proofs are placed before every member of the staff who has any concern with the facts set forth; that is, the official responsible for the stock should see that no lines appear in the list that are out of stock and likely to remain out of stock; the official responsible for fixing the prices of goods should see the prices, and so on. The importance of this can be realised when it is understood how serious a matter it may be for a firm if an offer of goods is scattered broadcast through the trade with a wrong price on the offer, or when no stocks are available.

If it is desired to draw special attention, in any particular issue of a catalogue, to some one line or item, this may be done by printing a line on the page in red, or by inserting a loose sheet with the necessary particulars. Of course, these methods involve extra cost, but the cost is usually worth while in such cases. Wherever possible, the price list should contain an easily detachable order-form, with everything tabulated as far as possible, so that all a would-be customer has to do is to fill in a figure stating the quantity he requires. It may be argued that anyone who is requiring goods will order them, whether there be a form handy or not, but all experience goes to show that the more you can help a man to give an order, the more likely he is to give it; and providing an order-form, so that the minimum of writing is required on the part of the customer, is certainly helping the buyer.

Making the Catalogue Valuable. There are various little devices by which a price list may be made additionally useful to its recipient. If it is at all thick, the various sections may be thumb-indexed in some such way as that mentioned below under the description of retail lists. Then it is of supreme importance that the dealer should keep the list at hand, so that he can refer to it easily whenever he wishes to do so, and for this purpose it is wise to eyelet the top corner and have a cord loop so that the list can be hung on a nail. In this way it will not only be handy, but its mere appearance hanging on the nail will be a continual advertisement to all who see it.

In some trades it is worth while to devote a page or more of the list to general information which is constantly in demand but is difficult to remember. Various weights and measures used in the trade, references to certain laws affecting the trade, hints, and so on, make the list valuable, and it is to the dealer's interest to keep it handy for this information. In this way you are getting him familiar with handling your list, which is one of the steps towards making him a regular customer. Along the outside of the cover in its greatest length can be printed a rule, of six inches or more, marked off into eighths, or with any other particular measurements commonly used in the trade.

Loose-leaf Catalogues. The latest development in the production of trade catalogues is that adopted by some large manufacturers and importers of special patented machinery, who issue loose-leaf catalogues which they lend instead of give to probable buyers from whom they get inquiries. The cover is in the form of one of the many patent files on the market, and any sheet can be easily removed or added to the list at any particular place. The advantage in this is that the lists are kept up to date, but, of course, such a system can be adopted only where the list is lent.

Distributing the Lists. Having produced a serviceable and attractive price list, it remains to distribute it, so that it gets into the hands of the people for whom it is intended. The usual method is, of course, to do this by post, and envelopes should always be used. A list enclosed in an ordinary wrapper with open ends is so obviously printed advertising matter that it stands far more chance of being thrown away unopened than of being taken from its wrapper and perused. For this reason envelopes should be used. They should be of fair quality, and it is better to have no printed matter—possibly not even the name of the firm issuing the catalogue—upon the envelope. Curiosity will then almost certainly ensure the list being taken out and looked at.

In posting lists, always use adhesive stamps instead of sending the packages to a post-office in bulk to be franked. The franking process—in which no adhesive stamp is used, but merely the word "Paid" in a circle is impressed on the wrappers—renders each package so obviously one of thousands that the recipient is quite likely to throw it away unexamined. In posting catalogues in large quantities it is, of course, unnecessary to use penny stamps. Halfpenny stamps are quite sufficient, the flap of the envelope being turned in.

Export and Special Lists. Firms that are doing a big export trade usually produce one or more export lists. One list, for example, may be for America, another for South Africa, and another for Australasia. In such cases, it is well, for the sake of distinction and in order to avoid confusion, to use a different coloured paper for each particular list. Thus pale pink might be used for the home list, buff for the American, blue for the South African, and green for the Australasian. The advantage of this is that the same design may then be common to all, and yet the distinctiveness remain.

For the Continental countries and for South America the lists would probably have to be in foreign languages, and it is quite usual for manufacturers and merchants to combine the principal languages into one list. Thus, the particulars of each article might be given in English, and then underneath in four columns, in smaller type, the matter might be repeated, translated into French, Spanish, Portuguese, and German. If a South

American trade is being catered for, it is necessary to use both Spanish and Portuguese, for not only is Portuguese spoken in Brazil and Spanish in the other countries, but there is much jealousy in regard to the language question among the South Americans; and even if a Brazilian could understand a list in Spanish, he would resent the fact that it was not in Portuguese.

These translations have to be made very carefully, and it is not enough to leave the work to one of the many translation bureaus that are found in all our large cities. Their idioms are often very faulty, they are somewhat hazy on trade and technical terms, and the result of their efforts should be checked by someone actually in the trade who understands the language in question. In food catalogues, all English measurements given in directions need to be not simply translated, but changed into the metric system—pints into litres, and so on. This question of translating the matter of a catalogue into the language of the country to which it is being sent is very important, and no firm that intends to do business should omit it. It is by our failure to make ourselves and our products understood in this way that we British have lost so much trade in the past to Germany, who, wherever she has gone, has been wise enough to advertise to the buyers in their own language. The prices, too, should always be in the money of the foreign country and not in English coinage, which the buyer is not at all likely to comprehend.

Other points worth remembering when preparing a trade catalogue will be found set forth in the particulars, below, of retail lists. As already explained, although they are entirely different propositions, there is much that is common to both kinds.

Retail Catalogues. Retail catalogues vary tremendously in size and appearance, according to the firms which issue them. The preparation of a large catalogue such as the great department stores send out to their customers will be described, and it will be understood that smaller establishments issue similar lists, but on a smaller scale. The great store must get into its list practically everything that the public uses, and the majority of these things must be illustrated. The blocks are, in the majority of cases, stock-blocks, some, such as brushes, tools, dish-covers, etc., being supplied by the firms that make and sell electros to printers; and others, such as proprietary articles made by special manufacturers, being supplied by the manufacturers themselves. The customers of these great stores are in the habit of doing all their shopping at their favourite establishment personally or by post or telephone, and for this reason it is essential that everything from a pin to a motor-car should be in the list.

Arranging the Items. The great stores and all similar establishments are arranged in departments, and it is the custom—a custom proved to be the most convenient by long usage—to arrange the matter in the lists in a similar way. The particular order in which the departments are given in the list is not essential, but it is customary for the grocery department to stand first, although this is not invariable. Whatever particular arrangement, however, is decided upon, it is wise to place the essentially household departments close together in the early part of the book—grocery, ironmongery, etc.; and the clothing sections, hosiery, tailoring, dressmaking, lingerie, drapery, etc., should also follow one another.

The arrangement of departments having been settled, the next point to be decided is the order of the various items in each department. No invariable rule can be followed; for while grocery with its hundreds, if not thousands, of lines is best arranged alphabetically, such a system cannot so well be followed in jewellery, where page after page will deal with articles of the same kind, like clocks, watches, etc., the alphabetical idea being thereby lost. As far as possible, however, the alphabetical arrangement should be followed, but any necessary departures are met by the copious index, which will enable a searcher to find without delay any particular line he or she wants.

Of course, there are many headings that will come in a particular department, such as the grocery, which will themselves have a large list of sub-headings indented under them. Take, for instance, biscuits. This will come in its proper place under B, and then there will be the various kinds of biscuits, the whole list being indented one or two ems. In some stores' catalogues, as many as 240 different kinds of biscuits are mentioned by name. This is only an instance, but there are many such. Hence it is necessary to give the main entries in a black type, so that these sub-lists of varieties can be distinguished by printing them in a smaller and lighter type for distinction. In the case of the heading "Biscuits," it is well to give under it only the varieties of biscuits for people. Dogs' biscuits should be a separate main heading, thus: "Biscuits, Dogs'. See Dogs' Biscuits." Common sense must be used in such matters when compiling the lists.

Preparing the Matter. From the nature of things in a catalogue of this kind there can be no long description of the majority of the items. In fact, in most cases there will be simply a picture, with two or three lines of descriptive matter, a list of sizes and prices, and a reference number which can be quoted in ordering. Special lines, new inventions, and so on will, however, be described more fully. A combined billiard and dining table on some new or unusual plan should have its mechanism and advantages set out fairly fully; furniture such as bookcases, pianos, gramophones, etc., needs more than the average amount of letterpress, as it is necessary to give a fairly full specification—style, wood, size, pattern, and so on. The grocery department will, of course, have fewer pictures than most of the other sections, although here facsimiles of the packages of proprietary articles will brighten up the pages and at the same time serve a very useful purpose described below.

Making up. Making up a list of this character is a big job; and while a good deal may have to be left to the printer, it is necessary for the advertisement manager or his deputy who is editing the list to indicate as far as possible the arrangement desired. In fact, the best method of obtaining a satisfactory result is to have proofs of all the blocks and all the cutlines and matter, and to paste them up page by page. After the pages have been made up, alterations in the positions of blocks and so on can be effected, but as little as possible of this kind of thing should be carried out, as it all means extra expense for corrections. A little more time spent on the make-up will obviate a great deal of this.

General Matter. In addition to the main catalogue in which the various articles for sale are described, there will be a number of pages of general matter, such, for example, as an almanac, a list of suburbs to which deliveries are made by motor-car,

and the days of delivery; regulations as to packing-cases and empties; plans of the various floors at the establishment, so that customers may be familiar with the topography when they visit the place; a list of departments; map of the district, with the position of the establishment clearly marked; a list of 'bus, tram, and train routes, nearest stations on various lines, and so on. In addition, there will be a title page; and at this point it may be mentioned that in sending out the lists to customers it is well to insert a few loose order-forms.

The Index. Next comes the index, and this must be very carefully compiled, and still more carefully checked, for nothing is so fatal to business as for a would-be customer to look up in the index a certain item she is in need of, and then, when she turns to the page indicated, to fail to find the article upon it. Of course, this means that before the index can be begun the pagination of the body of the book must be definitely settled. Many items may need a double entry, some proprietary articles, for instance, which would be given under the manufacturer's name where it was a household word, and also under the particular article in question. The type need not be large; and the page—if it is quarto size, the usual size for large lists—can be divided into four, five, or six columns.

Different Coloured Papers. It is a great advantage if the index and any other special sections to which it is desired to draw attention, or which it is wished to distinguish from the main body of the book, be printed on a coloured paper. Where an export section is given this could be printed on one colour and placed at the end, while the index could be printed on paper of another colour, and should always be placed at the beginning of the book.

At every opening of the book, the head of the left-hand page should have printed in bold, readable type—though not so large or black as to be ugly—the full name of the firm; and the top of the right-hand page should have the name of the department in which the goods described on the page are sold.

Thumb-indexing and Binding. The American system of thumb-indexing is a splendid one for large catalogues of this kind; and as it makes reference easy and therefore assists the customer, it must be a selling asset that is worth using. The various sections of the catalogue can be thumb-indexed in the same way as the books of a student's Bible are, and the alphabetical index itself may be divided at the margin in the same way.

Where a catalogue is going to run to a thousand pages or more, the binding should certainly be something more substantial and lasting than paper or cardboard. Such a book is an expensive production; it is interesting enough for a person to keep, but a flimsy cover will cause the corners of the pages to be dog-eared in no time. The book then looks very untidy, and is pretty certain, very soon, to be thrown away. If, on the other hand, the catalogue is bound in a good, sound, stiff cloth cover, the book looks far more important, its life is much longer, and it is a great deal more serviceable.

Manufacturers' Advertisements. The cost of turning out these very large catalogues such as the big department stores issue is enormous; and as they have to be given away free, the question of finding some source of revenue which shall help to pay the cost is an important one. Such a source of revenue does exist, and a very large sum is realised by letting space in the lists to manufacturers of proprietary articles for the purpose of advertising their specialities. These advertisements take a variety of forms. In the first place, there are a number of pages given up entirely to advertisements, and these are let as whole pages, halves, quarters, eighths, and in some cases sixteenths. The pages are sometimes distributed through the book singly or in groups, and sometimes they are grouped together at the beginning or end of the list. This latter arrangement, however, is not so satisfactory to the advertisers; and as in a matter of this kind it is always well that both sides should be mutually benefited, it will be better to distribute the pages instead of bunching them in one place.

Another source of advertisement revenue is found in the body of the list. Where proprietary articles are mentioned—and of course if the list is to serve its purpose and be complete it must mention them—a charge can be made for putting the manufacturer's name in black type, or at any rate in heavier type than is usually adopted for the various lines of goods. It will be found that in most cases the manufacturers will be willing to pay for such an advantage, or, rather, to be saved from the disadvantage of not appearing thus prominently when their rivals are adopting the plan. Many of the manufacturers who take space in the advertising pages and pay for the setting of their names in the body of the work in a bolder type will make it a condition that their advertisements shall face the quotations of their goods. This is a reason for distributing the advertisement pages through the book, as thereby an opportunity is given for meeting the wishes of the manufacturers in this respect.

An Alternative Plan. In order to give a greater uniformity to the catalogue, and to avoid the collection of advertisement pages at the beginning or end, or the dividing of the body of the work by such pages being distributed throughout, there is another plan which gives an excellent result, and is being adopted by some large stores. Instead of having whole pages given up to the manufacturers' announcements, a certain space—say, a couple of inches—is set apart at the foot of each page, and these spaces are let out at a fixed rate to the advertisers. Certain restrictions can be made as to the kind of blocks or type which shall be used, and this will prevent heavy and ugly blocks spoiling the general effect and distracting attention too much from the blocks illustrating the items in the list itself.

In many cases, second, third, and fourth covers can be used for advertisements at higher prices than the pages or spaces inside; and if the cover is cloth, or is printed in two or more colours, still higher rates can be obtained. Advertisers' own insets, too, can be taken, and either inserted loose or bound in when the body of the work is bound up. A certain number of these from the best manufacturers should be sought, as they are usually in colour, well printed on stiff paper, and form an additional attraction to the list. Carpet firms, china firms, soap and scent makers, playing-card printers, fountain-pen makers, and cigar firms are among those who prepare some very fine and attractive insets for this purpose.

The Cover. The importance of binding a big catalogue in a substantial cover which shall preserve the book in a healthy and presentable condition for the term of its natural life has already been referred to, but a word or two may here be said about the colour and design of the cover itself. These should certainly be attractive, but this quality must not be allowed to interfere with the serviceable character of the work. In colour, for

instance, we may select a cloth that is bright, but not so light as to be easily soiled. A grubby-looking catalogue is apt to convey an impression to the mind of the beholder which connects up the firm issuing the list with its appearance. A fairly dark-coloured cloth with a gold-blocked design is perhaps the best that can be selected.

In this design, on both the front of the book and on its back, the name of the firm or store must be the most prominent wording. If the building is a fine one, then a representation of it will enhance the appearance of the cover, and will familiarise the customer with it, so that when she visits the place, even for the first time, it will not seem to her strange. If, on the other hand, a card cover is to be used, the design should be a very attractive one—in colour if possible. On the cover should always appear the address of the firm, the telephone number, and telegraphic address. These should, of course, be repeated on the title page and at various places inside the book; and if they can be given, say, at the foot of every page right through the catalogue the convenience to the customer will be greatly increased.

Departmental Lists. Some large stores, instead of using one large and complete list of almost ungainly size, publish, at intervals of a week, month, or quarter, a series of departmental lists, one devoted to grocery, another to drapery, and so on. Each of these is, of course, of pamphlet size, with paper cover, and some are issued much more frequently than others. This method has its advantages, one of which is that it is less expensive than the big annual list system. Further, when prices are advancing, or otherwise, it enables the customer to have at hand at all times a list with current prices. But in the majority of the homes to which a list goes it is far less likely to be preserved if in the form of a pamphlet or series of pamphlets than if it is in the form of a large, well-bound, and well-illustrated volume of 1500 pages. The latter will probably have some definite place reserved for it in the home, and so will always be at hand when it is wanted. Thus there will be regular publicity all the year round. Anyway, if the departmental pamphlet system is adopted, every list sent out should, if possible, be eyeleted and corded, so that there may be an inducement for the housewife to hang it up in the kitchen for ready reference.

Local Lists. Where a firm has a number of establishments in different countries, as for instance in London, Edinburgh, Dublin, Toronto, Sydney, and so on, it is often the practice to issue local lists. The body of all these will be more or less alike, but the prices are arranged for each locality. In such cases it is best to use different-coloured covers for the various lists for distinctiveness, just as the manufacturer uses various shades for his home and export lists. On every local list of this kind all the addresses of the firm should be given in more places than one, so that people may take note of the various addresses if they are about to travel.

Lists for Small Establishments. The retail catalogue thus described at length is, of course, one of considerable size, such as only a great department store could afford to issue. But thousands of smaller retailers, right down to the moderate-sized grocer's shop in a town suburb, issue annual and half-yearly lists. These are, of course, little more than pamphlets. They consist of anything from 32 to 96 or 128 pages, and are prepared on the same lines as their more pretentious brethren. Octavo is the most usual size, but it is now getting the fashion to produce them in a long, panel shape, which is very convenient. They are usually more or less illustrated, should be well indexed, and certainly eyeleted and corded for hanging up.

Lists of this size are not usually arranged in departments, as, being for grocers' shops, chemists', or establishments of practically one trade, they have not the many departments of a great store. The method generally followed, therefore, is to put the whole list in alphabetical order from beginning to end.

It may be asked how a small tradesman can afford to issue a list, seeing that the expense of printing is so large. The answer is that he recoups himself for a very large portion of his outlay by securing advertisements from the firms from whom he buys his goods. They have a system of paying for these advertisements by making an allowance—1¼ or 2½ per cent.—on the total amount of business done with them during the twelvemonth; and thus, if the shopkeeper is doing a progressive trade, his list produces a progressive revenue which may more than cover the cost of printing and distribution.

The percentage arrangement is a much more satisfactory plan for all parties than the charging of a fixed rate per page. The shopkeeper, as he does more business with a manufacturer, finds his rate per page automatically increasing without any bother or effort on his part, and the manufacturer has no objection to paying a constantly increasing price for his announcement if a progressive rate means that he is doing a constantly increasing business.

Every retail list of this kind should contain one or two order-forms for the use of the customer into whose hands it falls.

Distributing Catalogues. Having produced an issue of a retail catalogue or price list, the all-important question now is, how shall it be distributed? First of all, we must know to whom we are going to send it, and secondly by what means we are going to get it into their hands. In the case of the large and expensive catalogues issued by the great stores, these will, of course, go only to customers of some standing. They are too costly to distribute broadcast, and even where applications are made for them such applications should be well sifted. There are always a number of people who are ready to obtain something for nothing, and among a certain class of people who are essentially non-buyers these great illustrated catalogues seem to exercise a strange fascination: they like to possess them. Others, again, are known to ask for such volumes in order that they may provide picture-books for their small children. Needless to remark, all such applicants for catalogues should be weeded right out, for lists sent to such people are absolutely non-productive. Only regular customers should receive the large bound volumes. A list of all persons to whom they are sent should be kept and revised each year. They should in every case be addressed to the customer by name, carefully packed so as to avoid damage, and despatched by carrier, as soon as possible after they are ready.

In the case of the smaller departmental lists, a wider distribution may be thought advisable. Every customer should receive a copy, whether he or she buys much or little, and in this case, of course, the lists will be forwarded by book-post.

The small retailer who issues a list will probably send copies round by hand to all his customers, and he may find it worth while to send also to people who are not customers, or, at any rate, not regular

customers. In selecting these he will take only the best roads, striking out any people who are notoriously bad payers, or for other reasons undesirable as customers. The remarks about posting given above under trade lists apply also to retail catalogues if they should be posted. They should always be sent in envelopes and stamped with adhesive stamps; and it is much better in such cases for the envelopes to be addressed by hand than typewritten, as the typed envelope to the lady of a house is more suggestive of circulars than a handwritten envelope. In many ways it is better for the small retailer to post his lists, as they are then quite certain to come into the hands of the lady of the house, whereas if they are delivered by hand they may never get beyond the servants.

Of the third class of catalogues referred to above —namely, those that are intended for the trade, but are so prepared that they may be shown to the public—little need be said. As mentioned, the best examples are those issued by the makers of gas and electric-light fittings. Builders and others show these to their clients, so that the latter may pick their fittings. The lists are compiled in just the same way as ordinary illustrated trade catalogues, but the prices given are such as the public will pay, the builder or other dealer getting a substantial discount, which is his gross profit.

The Standard Export Catalogues. Recently a new idea in export catalogues has found much favour with manufacturers. This is the Standard Catalogue system, which was initiated in 1910, and has now passed far beyond the experimental stage. The idea is a simple and valuable one, and is being carrried out most admirably by the Standard Catalogue Publishing Company, who have already issued about sixty thousand catalogues. Hitherto the overseas buyer has had to rely for his information, when purchasing, upon a heterogeneous mass of price lists of all sizes and shapes and styles. The mere multiplicity of style has meant that there was no adequate method of filing these, or of referring to them when necessary. The Standard Catalogue is a system of bringing all the essential information of all the manufacturers' individual lists together into one volume, or series of volumes, uniform in size and style, completely indexed, and available for reference at a moment's notice.

The great Standard Catalogue is divided into series: hardware and earthenware; cutlery, plate, and jewellery; textiles; groceries and provisions; drugs and toilet requisites; printing, stationery, and fancy goods; sports and toys; furniture and musical instruments; motor-cars, cycles, and accessories; building materials; and engineering. Some of these series are already issued, and have run into two editions, 1400 of the leading manufacturers being represented in two trades alone. Other series are in course of preparation; and as it progresses the work is, in the business world, becoming in fact what it is in name—the British Standard Export Catalogue. Manufacturers take so many pages, supplying matter and blocks, as they would for lists of their own. The matter is translated into French and Spanish, so that being in these two languages, and in English, it is practically available for most parts of the world.

The volumes are large, handsome books, strongly and handsomely bound, with the various sections thumb-indexed, and a copious index to make ready reference easy. A certain charge per page is made to the manufacturer, and the producers guarantee to distribute complete copies of the great work among the biggest and best buyers throughout the world, so that not only is the manufacturer able to issue an export catalogue at much less cost than if he did it himself, but he is absolutely certain of getting it into the hands of all the best buyers throughout the world, thereby securing all the advantages which may be possessed by his keenest competitors.

For the purpose of distributing the great Standard Catalogue, the producers have compiled, with the aid of the best official and non-official sources, probably the most useful list of export buyers that has ever been made up. The countries covered by the British Standard Export Catalogue include Canada, South Africa, Egypt, United States, France, Belgium, Russia, South America, Australia, New Zealand, East Indies, West Indies, Spain, Norway, Sweden, China, Japan, India, Straits Settlements, Malay States, Portugal, and Italy. Special attention is being given to those markets hitherto largely exploited by Germany.

Everything has been most carefully thought out. Each page, section, and volume of the catalogue has a three-letter cypher word to itself, so that any foreign buyer or manufacturer can cable a reference to any particular line at a minimum cost. Already with the series issued the position of the Standard Catalogue is so high that no manufacturer or advertiser who desires to do an export trade can afford to be out of its pages.

The House Magazine. A comparatively new form of advertising that is coming more and more into favour in England is the house magazine, and, as it is analogous to the catalogue and price list, it may be referred to here. It is a magazine issued periodically by a firm and sent to its customers and probable customers, in order to keep the name of the firm before them. It is a valuable medium for those firms who confine themselves to one or two particular commodities which are more or less steady in price, and have no reason for issuing price lists regularly. In America the idea of the house organ has been very extensively adopted, and has proved highly successful. It is from America that we have borrowed the idea.

While the main and primary object of the publication is to advertise the firm and its goods, it must not be a mere collection of advertisements cast into the form of a magazine. It must be distinctly a magazine in the true sense, with articles of general interest, and if the firm is a wholesale one these articles should be more or less connected with the business in which the firm is engaged. Thus, an engineering firm will find in recent achievements and discoveries a wealth of matter from which interesting, up-to-date articles can be compiled, and, of course, these should be well illustrated. The magazine should be nicely printed on good paper, and should have an attractive cover printed in two colours.

There should, of course, be a number of definite advertising pages, among these being the second, third, and fourth pages of the cover, and possibly some pages at the end of the body of the magazine could be given up to the same purpose. But, in addition, there are great possibilities in the articles themselves. A new machine or product that has really interesting points about it, especially if they have a bearing on modern scientific discovery or industrial and commercial development, is well worth a special article; and where anything technical and difficult can be illustrated by a picturesque and lucid diagram, explained in a popular style, the interest of the reader will certainly be arrested and held. CHARLES RAY

THE FOREST TREE IN THE TIMBER FACTORY

1. A SAWMILL AT THE MIDLAND RAILWAY WORKS AT DERBY

2. INTERIOR OF A SAWMILL AT A BIG ENGINEERING WORKS ON THE TRENT
The lower picture is by courtesy of Marshall, Sons & Co., Ltd., Gainsborough

Importance of Machinery in Woodworking. Woodworking Economy. Sawmill Arrangements. The Principal Machines.

THE MODERN SAWMILL

PRACTICALLY all the industries of the world are indebted more or less to woodworking machinery. The hand methods of the carpenter or joiner are not applicable to manufacturing in quantity, and machinery, therefore, supplants the human element, with resulting advantages from the points of view both of output and of accuracy. The classes of operations include those of cutting, scraping, and abrading, by which the cutting up and finishing of wood are effected. Both plane and curved faces are treated. The division of timber is carried out with saws in the first place, termed *breaking down* or *breaking up*, followed by *re-sawing*, which cuts it into smaller pieces of various shapes. These are further treated on machines which plane, mould, mortise, tenon, carve, dovetail, turn, bore, smooth, and polish as required, some of the operations being obviously unnecessary on certain work, while on other classes every one may be carried out.

There are five classes of machines used for converting logs into deals, flitches, planks, and boards. They are the *frame* saws, the *horizontal reciprocating* saws, the *horizontal band* saws, the *vertical band*, and the *circular* saws.

A Railway Sawmill. An excellent idea of the appearance of a sawmill may be gained from the photograph [1], taken in the carriage and waggon department of the Midland Railway Company's works at Derby, and shown here by the courtesy of the superintendent of that department, D. Bain, Esq. A large quantity of timber is used by the company in connection with the production of carriages and waggons, and carts, drays, barrows, etc., including repairs. The average annual output is 5500 new waggons and 200 carriages. A gantry is provided outside the mill, carrying two overhead travelling cranes, which pick the logs off the railway trucks, and set them on a cross-cut saw which cuts them up into suitable lengths. The mill, which has a floor space of about 10,000 square yards and is driven by engines developing about 800 i.h.p., has a cellar in which the shafting and belting are placed. An overhead traveller is seen in the illustration, holding a short balk, and various circular-saw benches and frame-saws are visible. The aim in the design of the mill is to keep the timber moving in a straight line as much as possible from end to end, passing on the way to machines that re-saw, plane, mortise, and tenon.

Figure 2 represents a rather different lay-out, and shows the interior of the sawmill of Messrs. Marshall, Sons & Co. The machine in the foreground is a horizontal band-saw, and a trolley track runs the length of the building for the easy conveyance of logs and sawn timber. The view illustrates the system of roof-lighting and the loftiness of the buildings.

Log-sawing Machines. The first operation upon logs coming into a sawmill is to part them off into suitable lengths for cutting down into boards, etc., unless it should happen that the whole length of a log is wanted. A direct steam-driven machine (Haigh, Gruban & Co., Oldham) is shown in elevation and plan in 5, with a log in position. The steam cylinder, A, by means of its piston reciprocates the piston-rod, and the saw-blade, B, attached thereto, the teeth being set to cut on the inward stroke. The reversal of the piston is not effected by ordinary valve gear, but steam is admitted and cut off by a valve, C, operated through the medium of the guide, D, which, sliding on the guide-bars cottered to the front cylinder cover, turns a flat twisted strip, E, as it moves, and causes the latter to turn a lever, alternately opening and closing the valve. The strip, E, turns easily by its round ends in bearing holes. The cylinder, A, is suspended by spigots in trunnion bearings on the baseplate, and a quadrant bolted on the rear has worm teeth upon it, engaging in a worm on a vertical shaft turned by the handwheel, F. This mechanism enables the attendant to raise or depress the saw-blade and to feed it downwards through the log. The latter is tied to the machine by two long rods pivoted to the baseplate, and having spiked ends, which are hammered into the log. The reason for making the saw cut on the inward stroke is that it is thus put in tension, and does not buckle as it would if pushed outwards. It may be mentioned that this method of steam-driving was originally devised by Messrs. Ransoms, of Newark-on-Trent.

Felling Trees by Sawing. An adaptation of this mechanism is made for tree-felling by turning the blade on its side, and employing a horizontal quadrant guide to let it slew around as the tree is cut through. A wedge is driven into the saw-cut after the blade, in order to keep the kerf open and prevent excessive friction on the blade. When these machines are portable, the steam is conveyed by a flexible hose from the boiler, which may serve several fellers and cross-cutters. Trees 3 ft. or 4 ft. in diameter can be felled in five or six minutes. Some large tree-fellers are mounted on wheels like a gun. A hydraulic jack, with a concave-headed ram, is employed to raise trees which have been felled and are being cross-cut, to prevent the blade from being pinched in the kerf; wedges are sometimes used instead.

Circular saws are not used so much as these reciprocating blades, partly because of their greater cost and the limitation in the diameter of log that can be cut through, but they work more rapidly.

Breaking-down Machines. Logs are divided longitudinally into portions of various sizes, known under different names, and the operation may be effected on a single machine or in two successive ones. Boards may be cut direct from the log, or the latter may be first broken down into deals (in the case of pine), flitches, or planks, which are further treated on other machines.

Log saws are those which begin work upon the logs and balks; *deal* and *flitch frames* are used for re-sawing the deals and flitches into boards. The first class of saw may be either a *log frame* or *timber frame*, a *reciprocating saw* or single-blade *board-cutter*, or a band-saw. The deal and flitch frames are of reciprocating type. Circular saws are

also employed for breaking down logs. Each kind has its advantages and disadvantages, which are discussed as the different types are illustrated.

Log Frames. The log or timber frames comprise a vertical *housing* through which the logs pass, and are divided by a number of saw-blades moving up and down. The frame-saw is the oldest type of machine, and is employed most extensively, though it is slower in operation than later machines which are coming rapidly into favour. The advantage is that logs may be divided accurately into boards, etc., without re-sawing, one pass sufficing for the operation. Means are provided for feeding the logs through at varying rates. The roller feed is suitable for straight, even timber, on which the rollers can get a good bite all along ; the rack feed is used for crooked, uneven logs, or on those which are frozen, and would not be gripped easily by rollers. The advantage of the roller feed is that the logs can be passed through quickly in succession, and there are no carriages to be run back for starting fresh logs, as in the rack feed, the result being a considerable saving in time.

The rack feed is more positive, and is better for hard woods, on which rollers are liable to slip under the strain of feeding. The rollers and the carriages are actuated by a feed motion derived from the driving mechanism of the machine, arranged so that the feed is imparted just before or on the down stroke of the saws, which, as they cut only in one direction, cannot have a continuous feed, as band or circular saws may. The saws, which, to work efficiently, must be strained very tightly, are fastened in a *saw frame* or *working frame*, or *swing frame*, or *saw gate*, with cotters and *buckles*, and the frame slides up and down between guides which are adjustable to take up slackness.

There may be only one, two, three, or four saws for opening out a log into thick pieces, which may or may not be re-sawn, or 40 to 50 blades can be used for cutting a log into thin boards. A frame must be strong enough to resist bulging out sideways when all the saws are cottered or *hammered up* in it, otherwise it will bind in its guides, although many machines embody provision for a little latitude in this way, so that if the frame is bulged it will still slide freely.

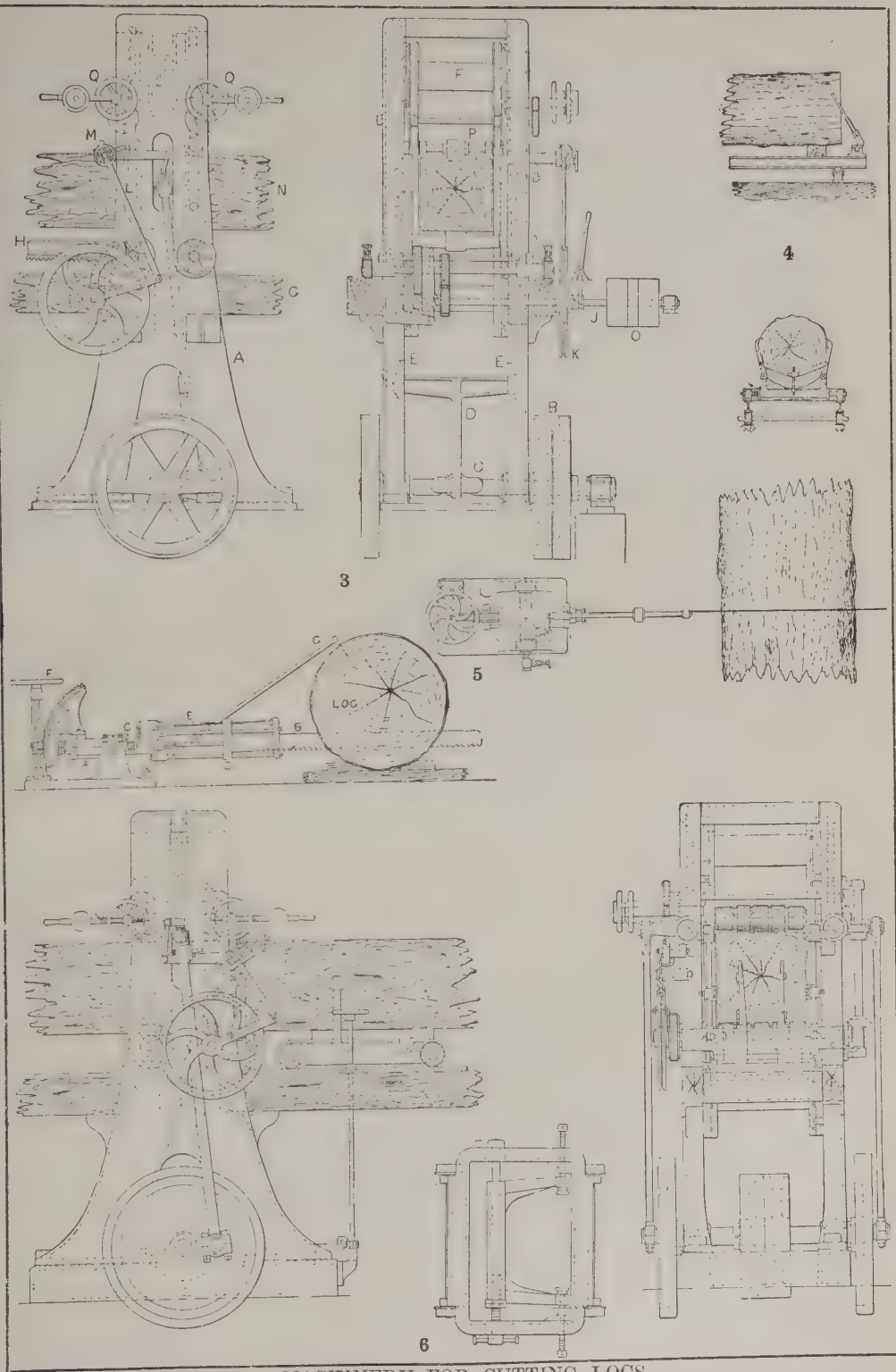
Log Frame with Rack Feed. Taking up the details of log frames, we first give side and front elevations [3] of a 24-in. frame, with rack feed, by Messrs. Haigh, Gruban & Co. The upright cored frame, A, which is seen to be well spread out, in the side view, receives all the working portions, and ensures rigidity and freedom from vibration. The fast-and-loose pulleys, B, drive the crank-shaft, C, the heavy flywheel on the other end of the shaft steadying the running, which is apt to be irregular, as the saws cut on the down stroke and run free on the up stroke. The combined connecting-rod and crosshead, D, couples the crank-pin to the two long rods, E, E, which are pivoted to the saw frame, F, sliding between the guides in the frame, A.

The timbers, G, G, bolted to brackets on the frame, A, are for the purpose of carrying rails upon which a *rack carriage* runs, the top of G being at the floor level of the mill, the rest of the frame and driving mechanism lying, therefore, below the floor. A bit of the table is seen at H, and on top of this the log is supported in a manner which will be seen later. The *feed* to this table is effected through a row of rack teeth on its under side, worked by pinions on a shaft lying immediately below it, and connected by two sets of gears with another shaft, J, having a large wheel with a rim of V section. This is given a partial rotation at each down stroke of the saw-gate by a smooth pawl cut eccentrically to jam into the vee as the lever, L, lifts it, through the medium of the short slotted lever, M, rocked up and down by a lever coupled to the top end of one rod, E. The position of the lever L on M is variable by means of a short screw and a hand-wheel which makes provision for obtaining different rates of feed to the balk, N. The device, which is universally adopted, is termed the *silent rachet* or *silent feed*. A rapid motion can also be imparted to the table in either direction for bringing a log up quickly or returning the carriage for another log.

The belt pulleys, O, carry open and crossed belts, either of which may be slipped on to the central fast pulley to drive through the shaft, J, clutched into or out of action, and connected to the pinions driving the table through two sets of gears having varying ratios, either of which can be employed, for fast or slow movements. The timber is held down firmly by rollers, P, on shafts which are supported in sliding racks moved up and down by pinions and gears, operated by the handwheels, Q, Q, which have weighted levers allowing a little freedom of movement should the log require accommodation in passing through. Two rollers are located beneath the log, so that it is held steadily.

Figure **4** illustrates a class of dog commonly employed for gripping the log at each end upon the rack table, the pincers or jaws being connected with toggle levers, and opened or closed by means of a central screw. The set of levers is carried on a shaft held in bearings, and a screw is placed at one side to enable the attendant to adjust the dogs laterally to suit crooked timber.

Log Frame with Roller Feed. The roller-feed frames, of which an example is given in **6**, propel the log by the contact of fluted rollers, positively driven. In some machines rollers are used only beneath the logs, the top rollers being simply plain, but in the *compound* types both top and bottom rollers are driven, thereby giving a powerful drive which will even carry logs covered with ice past the saws without slipping. In the drawing of the machine (also by Messrs. Haigh) several points of similarity to the previous design will be noted, but the mode of driving is different, being effected by belt pulleys located on the shaft at the bottom, rotating crank-discs at each end, and moving connecting-rods on the outside, connected to extensions of the saw-gate. The feeds are derived similarly to those already described, with a silent V wheel, but the motions have to be conveyed to the four shafts of the serrated feed-rollers, which are revolving simultaneously, by connecting them up with mitre gears and shafts. The log is supported on two carriages, one being shown in the side elevation and separately in plan view, running by trolley wheels on the rails secured to the top of the beams that are flush with the mill floor. Each carriage has a pair of pivoted arms carrying screws which clamp the timber, and as the arms are held on a shaft they are able to slew a little should the log rise or fall in passing through the feed rollers. The screw forming part of the pivot shaft [see the plan, **6**] provides for side adjustment to suit crooked logs. The machine is arranged also to saw deals, for which purpose a couple of *fences* (seen in the front view) are placed in position, and side pressure is given to the deals by flanking levers which are mounted on vertical shafts, twisted by quadrant racks operated by handwheels. When it is impossible to get out



MACHINERY FOR CUTTING LOGS

3. Log frame with rack-feed **4.** Dog for gripping logs **5.** Direct steam-driven cross-cut saw **6.** Roller-feed frame

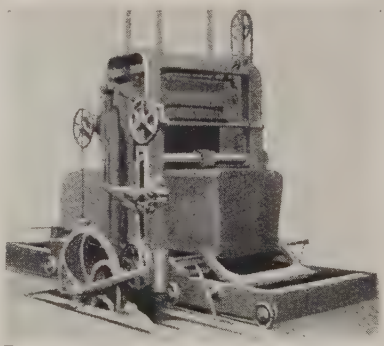
5873

deep foundations in the mill, *top-driven* frames are installed, by which the length of frame below the floor is reduced to a small amount.

A very heavy Robinson frame, constructed for cutting up massive logs of round or square section, is illustrated in **7**, with a big log in place. The capacity of the largest machine is up to logs 48 in. by 30 ft., the pulleys making 100 revolutions per minute. The connecting-rods work on the outside of the frames from crank-discs below the floor, and the feed is by a silent ratchet and fluted rollers of *duplex* or compound pattern, the bottom ones being driven by spur gears and the top ones by pitch chains. The frame shown is carrying 36 saws.

Semi-Portable Frames. In what are called *colonial* breaking-down frames, the uprights and horizontals are often constructed of timber, built on the spot where the machine is erected, the makers of the frame supplying only the iron portions. The machines are then of *semi-portable* type—that is, they can be readily dismantled and removed.

Portable Frames. The strictly *portable* frames are mounted on trolley wheels, as in **8** (A. Ransome & Co., Ltd.), with shafts and all appliances for hauling. The machines are drawn into an excavation of sufficient depth to allow the horizontal sleepers, on which the log carriages travel, to rest upon the ground; the carriages run upon the rails, which may be continued out to any length desired. Belt driving is adopted, working a central crank, connected to the crosshead of the saw-gate. The feed is derived from an eccentric or slotted disc on the face of one flywheel working up by a rod to the silent V wheel, this being a method often followed instead of getting the movements from the saw frame itself.



7. HEAVY ROLLER-FEED LOG FRAME

Double Frames. *Double* log frames have two sets of saws, which operate on two different logs simultaneously, though at different rates of feed, if necessary. The capacity is thus greatly increased without much increase in space occupied. In what are termed *equilibrium* frames, the two sets of saws are worked up and down by connecting rods attached to cranks at different angles, so that as one frame is rising, the other is going down, thus balancing the irregular forces, and enabling steady running to be obtained without the use of heavy flywheels.

Steam-driven Frames. The steam engine is applied to log frames in a direct manner, by attaching the piston-rod of a cylinder placed on top of the frame to the crosshead of the saw-gate to produce the reciprocal movements. Two advantages accrue: deep foundations are dispensed with, and the machine is independent of belting and other engines, which may be already fully loaded, although at the same time there is steam to spare from the boilers. A steadying effect is obtained by carrying connecting-rods down from the saw frame to cranks on a flywheel shaft just below the feed rollers, this shaft also operating an eccentric to work the cylinder valve. Sometimes one of the flywheels is turned to receive a belt, driving on to the pulley of a separate circular saw for re-sawing the product of the log frame.

The rates of feed employed on log frames vary from 6 in. to 5 ft. per minute, with quick return. The travel of the saw teeth ranges from 450 ft. to 800 ft. per minute. The output, of course, varies enormously, according to the class of timber and the condition of the saws.

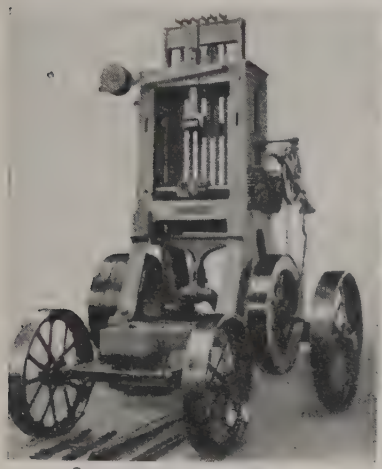
Deal and Flitch Frames. The deal and flitch frames are constructed for re-sawing deals and flitches *broken out* from logs in the log frames. They bear some resemblances to the latter, especially in methods of driving, but the feeding arrangements are modified, chiefly because the deals are not irregularly shaped like logs. The double principle is also carried out more frequently for sawing two deals at once, and even then the frames are narrow by comparison with those for logs, as the deals are sawn edge-ways up. Overhead-driven and under-driven frames are employed, as in log machines. The timbers are fed through the machines by fluted rollers, which are pressed on the under side and top of the deals as well as at the sides. These side rollers are carried on springs to take up automatically any unevenness in the thickness of the deals. The frames are arranged to take four of five saws per inch in width, as against the coarser pitching in log frames, of one per inch, or thereabouts. Speeds are higher than for log sawing, ranging from 600 ft. to 900 ft. a minute, and feeds up to 8 ft. per minute.

Double Deal Frames. The double feed frames are usually preferred on account of their greater output, the single ones being employed in sawmills where there is not a sufficient volume of work to keep a double frame properly occupied. The speeds of frames range up to as high as 360 revolutions in the equilibrium types, but these high speeds are not possible when the frames are worked from a single-throw crank-shaft. The reason for combining deal-sawing apparatus with a log frame is that many users have insufficient work to warrant the installation of both a log frame and a deal frame. The combination machine, therefore, meets cases of this kind. After a number of logs have been broken down into deals and flitches, the deal-sawing apparatus can be set up, and boards can then be cut.

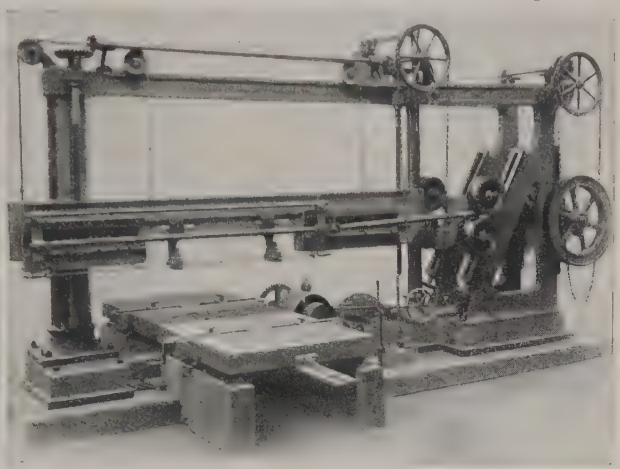
Horizontal Saws. We may now leave the vertical reciprocating saws and consider those of horizontal type, which are confined to one pattern, employing either one or two blades. They are used for cutting up hard and expensive woods, and, though not so rapid in action as the frame-saws, they possess some advantages.

A very thin saw may be employed, which wastes a minimum of wood in sawdust, and the power consumed by the machine is small. A very important point is that, the boards being sawn but one at a time, the sawyer may examine the timber, and alter the cut for any one board in order to avoid bad places concealed inside. The *figuring* of the timber may also be watched when cutting up for wainscoting or cabinet-work. In a frame-saw there is no chance to do anything of this kind, because all the blades are set, and must complete the division of the log simultaneously.

A 36-in. horizontal *board-cutter* (as these machines are called) is shown by elevation, plan, and end view in **12** (Haigh, Gruban & Co.). The framing comprises a bedplate supporting two standards, on the front faces of which a saddle, A, may be adjusted up and down by screws, operated by a hand wheel and bevel gears, or through a belt-pulley. The saw-blade, B, is strained between the extremities of a light steel frame sliding in guides on the saddle, A, the blade being passed through two wood-packed guides, seen inside and below the saddle, these coming close up to the log. A long connecting-rod, C, is coupled with a pivoted joint to the end of the saw-frame, and embraces the pin of a bent crank at the other, the crank being turned by a belt-pulley, which, together with another, is made as a heavy flywheel. The crank throw is 14 in. The *log table*, D, travelling by rollers upon vee-shaped rails, is racked along through the medium of a set of gears which derive their motion in the first place from the stepped cones at E, driving thence a worm, worm-wheel, and rack pinion. High-speed movements, in either direction, can be given to the table by open and crossed belts on the pulleys, F, connected to the shaft of the table pinion. The table, which is made in any length required, has dogs at its edges, set inwards by screws, to grip the log and prevent it from rolling about.



8. PORTABLE LOG FRAME

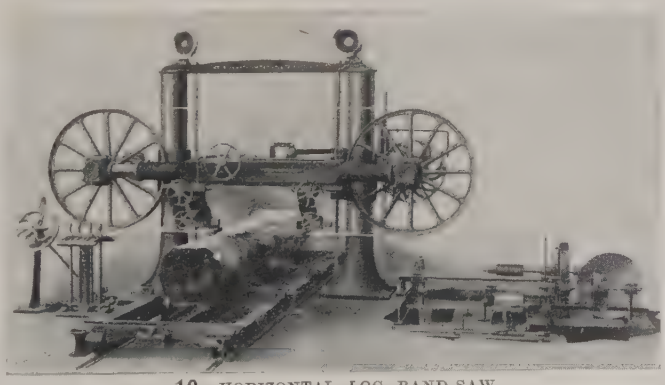


9. HORIZONTAL BOARD CUTTER

Figure **9** gives a good idea of the general appearance of a saw-frame, with a single blade, one of Messrs. Robinson's designs. The cross rail is adjustable on the pillars by hand or by power, and a graduated scale, recessed into one pillar, enables the sawyer to see the depth of cut in the log at a glance, and to make his adjustments accordingly. The crank-shaft, which is balanced, lies between the sloping standards to the right, and, with its bearings, is adjustable up and down the sloped guides, to keep the connecting rod in a central position relative to the saddle, as the latter is set high or low to suit the cut. The log carriage, a short portion of which is seen in the photograph, is fed by variable friction gearing, and returned at a high speed, all the controlling levers being brought to one place for convenience of operation.

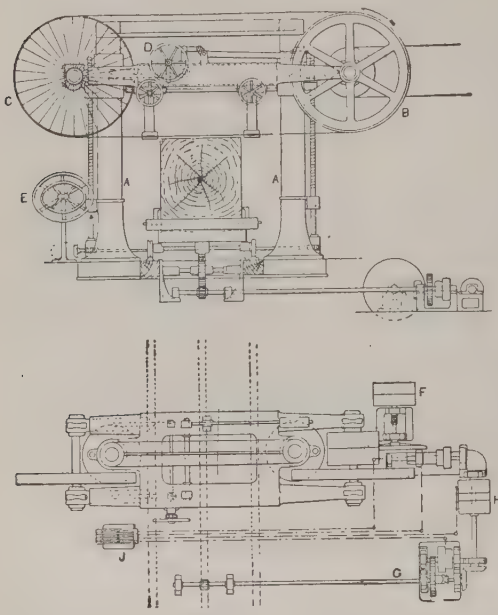
As the saws in the classes of machines described cut in both directions, the feed is continuous. The speeds of horizontal saws average 1000 ft. per minute. Rates of feed lie between a few inches and 5 ft. per minute.

Band-saws. All the reciprocating saw machines which have been described suffer from one defect—slowness of cutting. There are two classes of saws which work at a far greater rate, the band and the circular. The former especially is entering into rivalry with the frame-saws, and in many cases ousting them from their position in the mill as log-converting machines, a fact due to the enormous cutting capacity of the saw, a steel ribbon having teeth running at a rate of 7000 ft. per minute. The feed is correspondingly increased, ranging from 5 ft. up to 80 ft. per minute. A subsidiary advantage also gained by using band-saws is that, the blades being very thin (from 16 to 19 gauge, B.W.G.), the waste of wood in the kerf (say, $\frac{1}{11}$ in. wide) is greatly lessened by comparison with the thicker frame-saws; when dealing with costly timbers this matter cannot be ignored.



10. HORIZONTAL LOG BAND-SAW

Horizontal Band-saws. Band-saws are constructed in two types, horizontal and vertical. A horizontal machine by Messrs. Haigh, Gruban & Co., illustrated in front view and plan by **11**, embodies the principal features found in such saws.



11. HORIZONTAL BAND-SAW

Two circular pillars, A,A, bolted to a bedplate, receive sockets supporting a cross-rail, in the ends of which the bearings for the wheels, B, C, are held in pivots, to let the wheels align exactly with the saw. The pulley B is driven from fast and loose pulleys on its shaft, and it is of heavier construction than the other pulley, C, as the latter is an idler, driven only by the saw. The blade passes through *guides* seen adjacent to the log. Tension is given to the saw by pushing out the pulley C in a socket bearing by means of the handwheel, D, operating a worm gear and screw. A balance weight arrangement (seen above the cross-rail, adjacent to D) maintains an even tension on the blade when running by keeping a pressure on the pulley socket. The entire affair is raised or lowered on the columns, A, A, by two screws, worked from worms turned by a horizontal shaft driven through bevel gears from a handwheel, E. An indicator shows the attendant how thick a board will be cut.

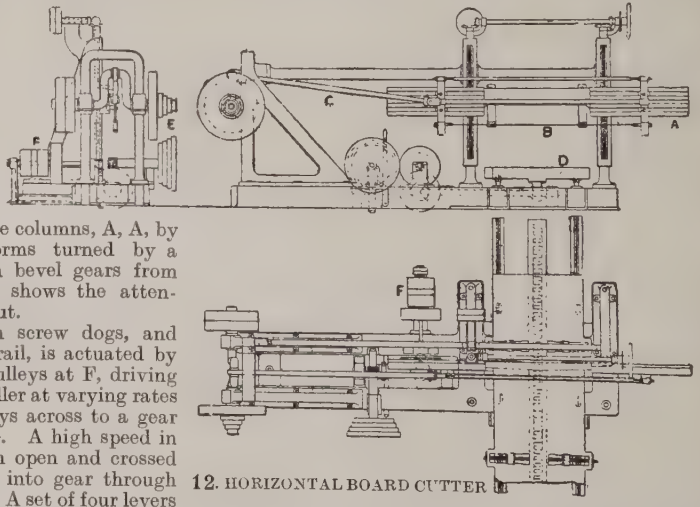
The log carriage, fitted with screw dogs, and travelling upon a V and a flat rail, is actuated by rack and pinion from the belt-pulleys at F, driving a friction disc, which rotates a roller at varying rates and communicates by belt-pulleys across to a gear turning the rack pinion shaft, G. A high speed in either direction is obtained from open and crossed belts on the pulleys, H, thrown into gear through bevels, and a claw clutch with G. A set of four levers at the stand, J, connects by rods to the three belt-shippers and the claw clutch, so that the sawyer has complete control.

Figure **10** shows a machine by Messrs. Robinson, with a log in position, and the *feed works* shown by the breaking away of the floor. The attendant's stand in front of the left-hand pulley is also clearly shown. The pulleys are 5 ft. in diameter. The friction feed gear gives any speed up to 60 ft. per minute, and quick movements of the carriage are obtained independently.

Vertical Band-saws. The *vertical* log band-saws are rather less expensive to construct than the horizontal types, and they occupy less width in the mill, while they are capable of breaking down the largest sizes of logs. An objection to the design is that the lower pulley is partly or wholly buried under the floor of the mill. At the same time, very large pulleys can be used, as much as 9 ft. in diameter in the biggest machines, with wide and powerful blades. The difference in the attitude of the saw, lying as it does vertically, necessitates presenting the log sideways, and as the pulleys are fixed the log must be fed inwards for each cut.

Feeding Devices. Two modes of feeding other than by rack and pinion are employed largely in the States. *Rope feed*, suitable for very long logs, embodies a friction drive, or a separate steam engine to wind an endless wire rope around a drum, and pull the carriage in one direction or the other, for cut and quick return. Direct-acting *steam feeds* include a long steam cylinder lying below the carriage, with a piston-rod connected to it, so that as the piston is driven in either direction the carriage is drawn along, the rate of feed being variable by the sawyer admitting more or less steam by a controlling valve. A combination of a steam cylinder and a rope passing over pulleys is used.

Loading Appliances. A special class of appliances is employed for loading logs on to the carriages from a sloping *skid* upon which the logs are stored, lying parallel with the carriage. The *log turner* is a kind of friction winch, operating a chain, at the end of which there is a hook, to engage in the log, and roll it into position on the carriage, after which it may be turned and adjusted. The *log loader* comprises a steam cylinder fitted below the bottom of the log skid, and actuating arms



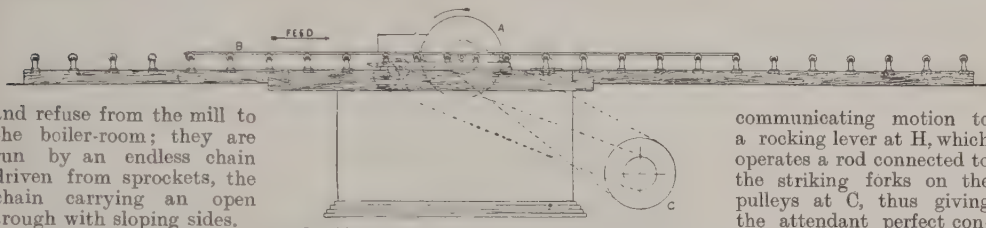
12. HORIZONTAL BOARD CUTTER

which release a log and allow it to roll on to the carriage of the saw. A foot pedal operates the steam valve. The *steam nigger* is the quickest

means of handling; it consists of a long, vertical *arm*, to which are attached hooked spikes. The arm is moved up and down, or canted by two steam cylinders of direct-acting type, and the spikes may be made to catch in a log, pull it from the skid, roll it on to the dog carriage, and turn it into any position most convenient for sawing. The skids are supplied with logs from a haul-up slipway.

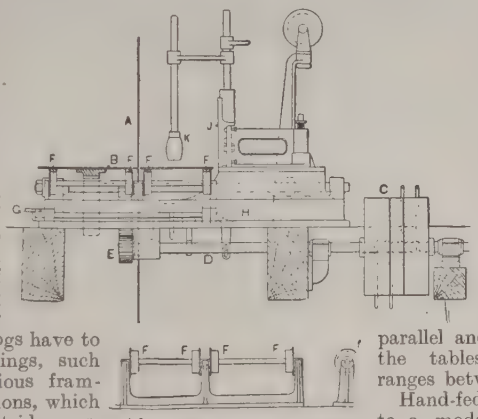
Live rolls, consisting of a train of rollers positively driven by bevel gears, are useful for transferring material from the band-mill to the re-saws, and they save a great amount of time which would be occupied by hauling about by hand and cranes. The timber is transferred to or from the live rolls by mechanism which avoids handling on the part of the men; the lateral motion is produced by an endless pair of chains, which are raised into contact with the lumber when desired, or by spiral rolls making contact underneath.

Sawdust conveyors are used to transport the dust and refuse from the mill to the boiler-room; they are run by an endless chain driven from sprockets, the chain carrying an open trough with sloping sides.



13. 72-INCH CIRCULAR SAW RACK BENCH

Circular Saws. The circular saw as a log-converting machine possesses the advantage of great speed of cutting, and outdistances the reciprocating saws easily in this respect. As a set-off, two objections are: that there is a considerable waste of wood in the kerf, and the saw takes an excessive amount of power to drive it, due to the leverage of the teeth acting on the periphery of the disc. Notwithstanding these objections, circular saws are employed when logs have to be cut into heavy scantlings, such as sleepers, posts, and various framings of square or other sections, which involves taking off the outside portions. They are not used to such an extent for the cutting of logs into very thin boards or strips of different sections.



14. DETAILS OF RACK BENCH

Rack Benches. The log saws are constructed with travelling tables, which carry the logs past the projecting saws. There are two patterns—one in which the tables are divided to embrace the saw on each side, the other in which the logs are held on dog-carriages and presented laterally to the saw, enabling successive settings to be made for cutting off planks or boards.

Figure **13** gives a side elevation of a *rack bench* for a 72-in. saw (Messrs. Haigh, Gruban & Co.), from which the elements of such machines may be studied.

The saw, A, runs in fixed bearings, and the timber rests upon the table, B, which has a longitudinal opening to receive the saw. The table is made of steel plate, and moves upon a series of rollers, seen underneath, resting upon a timber framing.

The driving of the saw is effected through the line shaft and pulley at C, belted up to the saw mandrel; the table drive is also derived from a pulley at C, from which a belt goes up to a pulley connected to a train of spur gears, coupled with the rack underneath the table. The rates of feed can be varied from 10 ft. to 40 ft. per minute, with a quick return movement at 120 ft. per minute. Some details of the machine are illustrated in **14**, the saw being seen at A, the table at B. The feed is from pulleys at C, carrying open and crossed belts, either of which is shifted on to the central fast pulley, driving the shaft D, and thence a train of spur wheels, which end in a pinion meshing with the rack fastened underneath the table B, to the left. The four rollers supporting the table across its width are seen at F F F F, all of these being mounted upon a common spindle. There is a foot pedal at G, which, when depressed one way or the other, turns a short shaft having mitre gears communicating motion to a rocking lever at H, which operates a rod connected to the striking forks on the pulleys at C, thus giving the attendant perfect control over the feeds and return. The *fence* at J is for guiding timber in a straight line past the saw, and to keep the timber against the fence the *pressure roller*, K, is brought into use. It is held on an upright bar that can be pivoted in its socket, and pulled over by a cord attached to a balance weight, the cord passing over the pulley adjacent. In this manner the timber is pressed up to the fence, and the resulting cut is parallel and smooth. The length of the tables in these rack benches ranges between 20 ft. and 40 ft.

Hand-fed rack-tables are made only to a moderate extent, the motion being obtained from a crank handle turning the rack pinion. No fastenings are necessary for the logs, as their weight is sufficient to keep them steady. Round logs are flattened on the bottom to make them stand firmly, or else wedged and packed to keep them from shifting.

Rack Benches with Dog Carriages In **15** we illustrate a machine (Messrs. Thos. Robinson & Son, Ltd.) in which a log is seen gripped by some of the quick-acting dogs of the carriage. The carriage as shown is arranged to take logs up to 30 ft. in length, but there is practically no limit in this direction. The circular saw is 66 in. in diameter, and runs at 500 revolutions per minute. There are three speeds, or rates of feed, to the log, and a rapid return.

A circular steel disc of wedge section is placed immediately behind the saw, to enter the kerf after it, and force the two sawn portions apart slightly, thus relieving the saw of undue side-

friction, which would tend to heat the saw, greatly augmenting its work and decreasing output. There is a long, vertical roller located in a sliding bearing in advance of the saw, against which the log takes a bearing when travelling. The roller is adjustable by a hand wheel, and serves as a fence.

Double Saws. As the capacity of a circular saw is limited as to the diameter it will cut, it cannot be employed to cut up big logs. But by mounting another saw above, the capacity is much increased, as the two blades, working up from below and down from above, can reach through a greater thickness. The top saw is usually of smaller diameter than the bottom one—say, in the relation of 72 in. and 36 in. in the case of the larger machines. Figure **17** represents a double machine, a type similar in all other respects to **15**. The upper saw is carried on a spindle in sliding bearings on an upright, and the driving belt passes around a jockey pulley by which the slack is taken up. The teeth of the saws face in opposite directions to each other, and the direction of rotation is also opposite. The two are brought as close as possible without actually touching.

Re-saws. We now come to a group of machines termed *re-saws*, the function of which is to cut up deals, flitches, planks, etc., which have already been sawn out from logs, into portions of various sizes. The deal frames already described are strictly re-saws, but there are also the smaller band and circular saws, which are both rapid in operation and handy in respect of the variety of work which they can be adapted to turn out. Adjustments can be made very quickly to cut a small number or hundreds of similar pieces. A feature in which these circular and band re-saws differ from log-sawing machines is that the tables do not usually travel, but the timber, being more or less even, is slid along smooth surfaces, with or without the help of rollers. The three chief methods of feeding are rope, chain, and roller. The *rope-feed* is suitable for irregularly shaped timber or for driving small logs. The bench [**16**] (Thos. Robinson & Son, Ltd.) embodies a cored casting, carrying three bearings for the saw spindle. The timber is drawn along on the top of the table past the saw by a rope fitted with a drag hook at the end, as seen, and the rope is wound around the drum at the left-hand end of the bench. Four rates of speed, from 15 ft. to 60 ft. or upwards, per minute, can be obtained through the medium of cone pulleys, and the movement of the rope can be instantly started or stopped by throwing a clutch in or out of gear. The speed of the drum is reduced by back gears. The rope is passed up over a roller at the edge of the table, this roller enabling it to run over the edge without friction. In cutting long pieces which overhang the ends of the bench to a considerable distance, some extraneous support is required; this is afforded by a *trolley* at each end, running on lines of rails laid down in line with the machine. The timber, therefore, rests on one trolley, and gradually leaves it to pass over the bench past the saw and be supported by the other trolley. The fence for keeping the timber straight is fitted with a counterbalanced roller, pulled over by a weight, in a similar manner to that described in connection with **14**.

15. CIRCULAR SAW LOG MILL

16. SAW BENCH WITH ROPE FEED

Some rope-feed benches have, instead of the small drum, a large grooved wheel placed with its spindle at right angles to the saw mandrel. It lies close up to the end of the bench, and the rope is conducted over a small pulley on to the table. The rope is subjected to less strain while running on the large pulley than it is on a small drum. When the rope has been pulled along to its drum or wheel, the return, in readiness for another feed, is effected by pulling at it with the hands, the clutch being thrown out meanwhile, so that the drum revolves freely upon its spindle.

Chain-feed Benches. *Chain-feed* benches, which are employed principally for cutting up sleepers and the various short pieces of waggon framings, have a greater output than the rope-feed machines, because the action is continuous. One, or in some cases two, endless pitch-chains are driven over wheels at the ends of the table, and they run in grooves past the saw. The timber is fed by the pressure of dogs dropped on to the chains between the links. As the chain, or chains, are always running, the timber can be pushed along as fast as it is placed in position. Rates of feed vary from 40 ft. to 120 ft. per minute. Some machines will split 2500 balks in a day of ten hours, resulting in the production of 5000 sleepers.

Roller-feed Benches. The best method of feeding, providing the work is suited thereto, is by continuously revolving *rollers*, either horizontal or vertical, the latter method predominating. A horizontal roller bench is shown in **18**, one of Messrs. Robinson's designs. The rollers, which are smooth, lie at the ends of the table, and their top surface is raised slightly above that of the table. They are driven at any one of three different speeds, and the weight of the log, or flitch, combined with the downward pressure of the revolving saw, gives sufficient friction to feed. The rollers can be reversed at a quick speed, in order to return heavy pieces after each sawing. The largest of these machines takes saws up to 5 ft. in diameter.

One of the most useful forms of roller-feed bench is that shown by the drawings in **19** of a bench taking 42 in. saws, and having a table measuring 6 ft. by 3 ft. (Messrs. John Sutcliffe & Son, Ltd., Halifax). The saw spindle, A, is supported in two bearings, the outer one being placed outside the driving pulley. The latter is made slightly larger than its adjacent loose pulley, on which the belt is slid to run idle and slack. The belt slipper is seen to be actuated by a pivoted lever worked from a rod passing through to the front of the

bench, where the control is best effected [see the plan view]. Removable plates are fitted over the bearing and the spindle end, to facilitate examination and the changing of saws. The feed rollers, B, B, serrated in ratchet form, are revolved against the timber, and force it along while making contact with the fence, C. A number of small plain rollers are set in the fence, to relieve the friction. Lateral adjustment, to suit the thickness of wood which it is desired to cut, is effected by a transverse screw passing through the table, and turned by a small knob seen near the right-hand end. Quick adjustment is provided for by a locking handle, which releases the fence, enabling it to be shifted to and fro instantly.

The mechanism of the feeding rollers includes a radial arm, D, pivoting upon a pillar bolted to the table, and carrying a rod in clamp bearings, which rod holds the vertical shaft bearing of the rollers, and is adjustable in the clamp bearing to accommodate different diameters of saws. Pressure against wood is produced by a rope or chain pulling at the side of the bearing, leading over guide pulleys at E, to a weight at F. The rollers are driven in a positive manner by a pitch chain on the top of the shaft, worked from another shaft, G, which passes down through the table pillar to the floor, where a worm drive is received from a four-stepped pulley, H, belted from another pulley, J, which derives motion from a pair of pulleys, one on its shaft and one on the saw mandrel at K. A claw clutch, put into mesh by a handle at the front of the bench, enables the sawyer to start and stop the rollers instantly; the clutch works into teeth on the stepped pulley. At each end of the bench a smooth roller rests in bearings to take the weight of the wood as it passes over, and so to lessen the friction. If it is desired to use the machine without the roller feed, the radial arm can be swung out of the way, leaving the bench free.

17. DOUBLE SAWS FOR LARGE LOGS

18 HORIZONTAL ROLLER-FEED SAW BENCH

Combination Feeds. Several types of benches are constructed with a combination of feeds, as rack and roller, or rope and roller, the idea being to use one for rough logs, which cannot be fed by rollers, and the other for regular pieces, like deals. Such machines are very useful to sawyers who cannot have two separate benches for the different classes of work.

Canting fences are designed for use with the roller-feed benches, to cut feather-edged boards, etc. The fence tilts bodily with its rollers, so throwing the stuff over in relation to the saw.

Band Re-saws. Band-saws for re-sawing are not quite so handy as the circular saws for general work, but they are popular in many cases on account of the thinness of the blade and the minimum of waste incurred in cutting. It is not a difficult matter to fix a self-acting feed to a band-saw table. In a few types a short rack-operated slide is placed on top of the table, to traverse the stuff, but the majority of machines use friction rollers, either one set, propelling the wood in contact with a fence, or a double set, both of which roll against the timber.

Cross-cut Saws. We have to note the *cross-cut* saws, which are employed for parting off deals, planks, boards, etc., to definite lengths. A good deal of this work is of a repetition character, especially for box-making and joinery, and means are provided for cutting numerous pieces to gauged lengths by the employment of fences or guides, or by putting two or more saws side by side to cut off the ends accurately. The *pendulum* saw [20] (John McDowall & Sons, Johnstone) is a pattern that is very commonly used. It comprises a rigid frame swinging in trunnion bearings on brackets attached to the roof or the wall, and carrying pulleys which are belted down to the saw spindle at the bottom; the saw can therefore be swung to and fro by pulling at a handle in the front, while a counterbalance, on levers at the upper part of the frame, draws the latter backwards automatically on letting go the handle, so keeping the saw out of the way until it is required. The spindle is started and stopped by shifting the belt on the fast and loose pulleys at the top shaft. The stuff to be parted is supported on the special bench seen in the illustration, a gap being cut through where the saw swings across.

For cutting pieces to uniform lengths there is provided an adjustable *stopper* that can be clamped in any longitudinal position, for the end of the timber to butt against, and so locate it accurately. To save lining off the lengths of timber previous to cutting various pieces, it is sometimes the practice to fit a metal rule with clamp stops, so that accurate sub-divisions of the inch can be made by the sawyer. The largest saws used in these pendulum machines usually range up to 36 in., capable of working to 12 in. deep, but in a few instances saws up to 60 in. are employed for heavy work, including small logs.

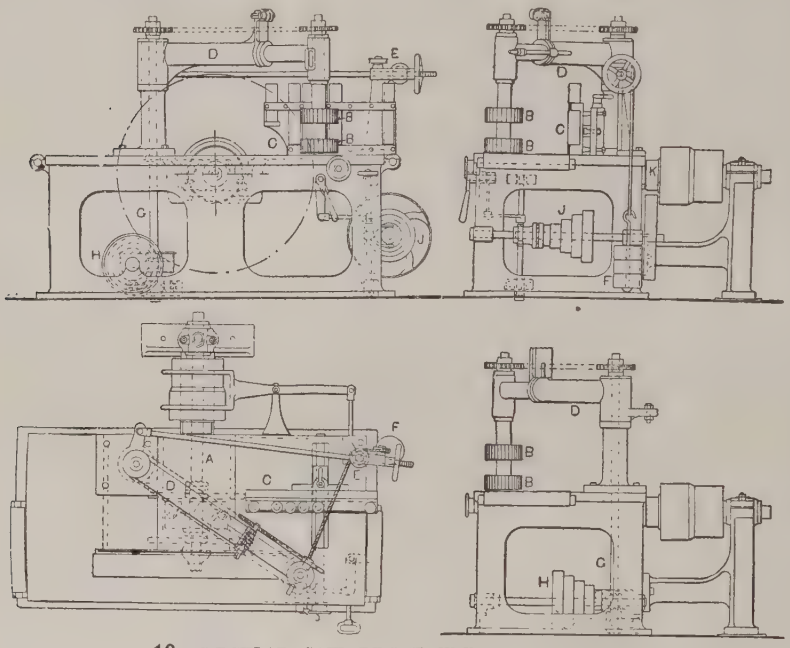
A guard is always fitted over the upper portion of the saw, as a protection against injury to the attendant at the machine.

Sliding Table Cross-cut Saw. The pendulum saw is especially handy for long or heavy pieces of wood, as they remain stationary. But when the length and weight of a piece permits, one of the several special cross-cut benches can be brought into use. The object is to traverse the timber across against the saw teeth, this being effected generally by a table running by rollers upon rails. The spindle is made to rise and fall in some of these machines. Double or *equalising* saws, which trim off the two ends of a piece simultaneously, comprise a table travelling above a bed on which two headstocks are set in any desired position, to give variable widths. As the stuff is drawn over on the table the saws part it off at both ends simultaneously. Lengths from 4 in. up to several feet are handled on these machines.

Multiple Cross-cut Saws. *Multiple* saw machines are principally of two classes. In one a number of saws are set side by side to the required distance to part off a length of stuff into several pieces, such as paving blocks, the movement of the saws or of the wood carriage being continuous, so

that at each stroke a piece of wood is completely cut up. Sometimes the saws are of differing diameters, gradually getting smaller, so that the work of sawing is gradual, and does not put so much strain on as though all the blades penetrated simultaneously. As many as 30,000 paving blocks can be sawn out in one day on these machines. In the other class of machine several saws are set in a long table, at differing distances apart, in order that stuff may be cut to various lengths, the pairs of saws being set in advance of each other, or, alternatively, sets may be caused to disappear below the table, leaving only those standing up which are required. The travelling tables are abolished in certain designs, and their functions performed by endless chains, having dogs which engage in the sides of the timber, and push it against the saws.

One particular design of bench, which differs from those already described, is intended to deal with heavy planks and scantlings that are too heavy to be conveniently handled about and fed to a saw. The timber is laid upon a fixed table, and cut by a circular saw projecting up through a slot therein, the spindle running in bearings that can be fed longitudinally on a subsidiary bed. The foregoing machines for re-sawing and cutting off prepare the stuff for further treatment (when required) on other kinds of saws, which we shall now deal with.



19. CIRCULAR SAW BENCH WITH ROLLER FEED

Plain Benches. The lighter types of circular and band saws, which are not fitted with mechanical feeds, appear in several forms, modified variously to suit the classes of work they have to do. The *plain* circular-saw benches resemble those in **18** and **19**, but without the special attachments required for feeding, the only fitting being a fence, which is adjustable to and from the saw. The usual method of attaching the fence is by means of a circular steel bar at the end of the table, enabling lateral adjustments to be made, or, if necessary, the fence can be thrown back out of the way, leaving the table quite clear for cross-cutting. For bevel cutting, a canting movement has to be provided for the fence. The larger machines have rollers placed at each end of the table, similarly to **19**, to assist in the easy handling of heavy pieces.

Portable Benches. *Portable* saw benches, mounted on four trolley wheels, are used by shipbuilders and contractors, the machines being run to any locality where they are wanted, instead of transporting the timber to the saw. An electric motor drives the spindle direct, and the table is swivelled upon a turntable, to present the saw at any horizontal angle to the work, instead of shifting the latter.

Rising and Falling Types. The range of the plain benches is rather limited, and other types are therefore used for an extended class of operations, especially in joinery work. In one type, with *rising and falling* spindle, the spindle may be moved upwards or downwards in relation to the table; in the other the movement is imparted to the table. The object in each case is to vary the depth of cut, so that the machines are adapted for grooving, tonguing, rebating, beading, and tenoning, by fitting special saws or cutter blocks to the spindle. The saws are either *thick* for grooving, or *drunken* for grooving and tenoning. The objection to altering the spindle height is that the belt-driving arrangements are complicated by the variations, and the rising and falling table machines are therefore preferred. The only disadvantage possessed by them is that the varying height of the table is sometimes apt to become awkward to the sawyer, but there is not much weight in this objection. There are two devices employed for operating the tables—racks and screws. The latter are better for the purpose, and are used in the majority of machines.

A groove is sometimes planed longitudinally in the tables to take a sliding fence, for use in cross-cutting, the fence lying at right angles to the main one; mitre cutting can be done by attaching a supplementary mitre fence.

Dimension Saws. The *dimension* or *two-spindle* saws are designed for both ripping and cross-cutting, and have two saws sharpened for cutting with and across the grain respectively. The spindles run in bearings at the opposite ends of a strong arm, pivoted about its centre in order that either of the saws may be brought up to the top ready for action, a hand wheel accomplishing this movement. The drive to the spindles is arranged so that the lower saw is thrown out of action. The special value of the dimension saws lies in repetition work, where large numbers of pieces have to be sawn

to uniform sizes, as in cabinet work, pattern making, parquetry work, etc. Angular and bevel sawing is readily done by the aid of the canting and swivelling fence.

Universal Benches. *Universal* saw-benches embody the two-spindle arrangement, together with a tilting motion of the table, to present the stuff angularly in relation to the saw. Several auxiliary fittings, as gauges and angular fences, are provided, so that every class of sawing can be done, to build up the most intricate framings accurately.

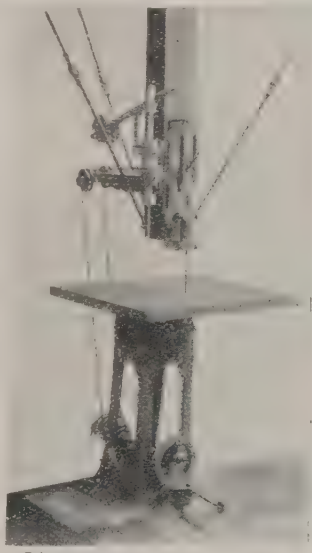
Band-saw Machines. The band-saw machines are particularly useful for general sawing which includes curved work, because they can tackle sweeps for which the circular saw is useless. The chief drawback is the trouble caused by breakages of saws, though this is often avoidable if care is exercised.

Figure 22 gives a good idea of a typical machine in side and front elevations, the example being from the practice of Messrs. Thomas White & Sons, Paisley. The saw pulleys are of 30 in. diameter and make 400 revolutions per minute. The framing, A, is of box section, cored out, which affords a very stiff form, able to resist the effects of vibration at the high speed necessary. The cast iron pulleys, B, C, have no flanges, and are rubber tyred to avoid damage to the saw teeth, and the top wheel C is mounted on a spindle which runs in a hinged bearing that can be tilted to make the saw run on any part of the pulley. The hand wheel, D, operates a screw which slides the bearing of the wheel C up or down to suit the length of saw, and a constant tension is maintained afterwards by the coiled spring at the top. A balance weight and lever is fitted in some machines instead of a spring. The belt drives to the fast and loose pulleys at E, and is shifted across to start or stop the machine by the forks and hand lever passing through the frame. F is the table, constructed with an extension to cover over the pulley B and prevent pieces of wood from falling on it. The table is tilted or canted for angular sawing by turning the hand wheel, G, which rotates a worm engaging in a worm segment on a quadrant bolted to the table, and turning the latter upon its pivot. The saw passes through a timber casing at H, and through a *guide* at J. Rolling contact is the proper method, and there are several designs of guides in use. The blade is confined sideways between two hardwood strips, adjustable for width of opening. The guide is brought down as close as possible to the stuff being sawn, and is therefore held in a vertical bar passing a socket in the frame A, in which it is clamped in any position by a hand screw. The bar is counterbalanced by a rope and weight to prevent it from dropping when the hand screw is loosened. The saw passes through hardwood strips let into the table, and a rotary guide is also often fitted below the table, though in some instances nothing but wood guides are employed. The lower saw pulley is in many machines provided with a little brush to keep the pulleys clear of sawdust, etc.

A fence is fitted to the tables of band-saws when wanted, to guide straight stuff past the saw, otherwise the operator must work to a scribed line on the timber, as in sawing curves.

20. PENDULUM CROSS-CUT SAW

Fret or Jig or Scroll Saws. These have but a limited scope, and are used for internal cutting and scrollwork which a band-saw could not manage, as the fret-saw blade can be disconnected and passed through a hole in the piece to cut out a central portion. The mechanism is simple, comprising a small crank-disc driven at a high speed, working a connecting-rod which reciprocates the saw-blade, gripped in sliding holders above and below a table. The rate of working is about 1000 strokes per minute. There are two types of machine; one has a curved cast-iron framing reaching round the table and up to the top holder, the framing, therefore, preventing very large work from being placed in position. In the other type, a suspended tension head of wood is used, consisting of a vertical beam attached to the ceiling, and strained tightly by three tie-rods, put in tension, by nuts on right and left-hand screws [see 21]. The entire space around the table is free, and work of any area can be put on. In the machine illustrated, tension is given to the saw by means of a couple of spiral springs, which constantly maintain an even pull. A boring attachment is shown alongside the framing, to prepare work by making holes where they are necessary to insert the saw.



21. FRET-SAWING MACHINE

Saw Details. Devoting now a brief space to the consideration of the saws which are used in the various machines hitherto described, we begin with the frame-saws. The types employed in the log and deal frames [23, A and B] are long, flat blades, or *webs*, to which are riveted *buckles* [*a*] held at the bottom end of the swing frame by a hooked portion, or by a head, and strained up in the top by *tillers* and cotters. Enlarged views of the buckles and cotter are given in C. The horizontal board-cutting machines have saws like D, attached and strained with buckles and screws tightened up with nuts.

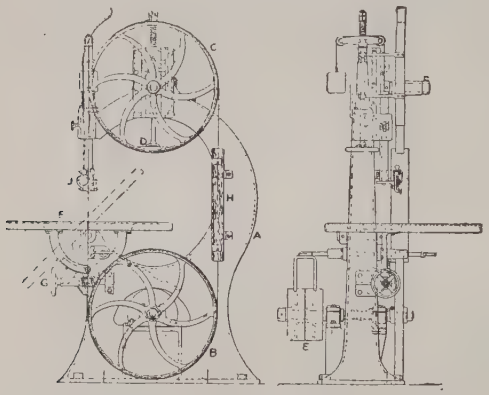
The shapes of the teeth for such saws are shown in 24, A and B being triangular, with a moderate amount of radius at the roots, C, with a *gullet* tooth, while the horizontal machines use webs with double sets of teeth, placed in reverse fashion, D, to cut in both directions alternately.

Band-saws. Band-saws are necessarily very flexible, to lap around the pulleys, and endure the constant bendings and straightenings which go on, and the temper must be uniform throughout the blade, in order to avoid cracks and breakages. The sizes range from $\frac{1}{8}$ in. to 16 in. wide.

The most common shape of tooth is that at A in **25**, while other shapes are shown at B, C, and D, with a greater amount of radius at the roots. The pitch, or distance apart of the tooth-points, is greatly varied, according to the size of the saw and the class of work which it has to do. Thus an $\frac{1}{8}$-in. blade will have nine teeth to the inch, $\frac{1}{4}$-in. six, 1-in. three, and so on. The blades are made in lengths, from which bands of suitable size are prepared by brazing the ends together.

Tension of a Band-saw. The *tension* of a band-saw blade relates to a certain slackness of the centre, produced by a hammer, or by rolls, the effect of which is to cause the blade to bear on the pulleys with its outer edges, and not in the middle plane. The amount of tension varies for different saws.

Another point is that, to run properly, the back of the saw must be perfectly straight. A long straightedge is applied to test the accuracy or otherwise, and the matter put right by hammering or by rolling. Should the back be concave, the surface is



22. THIRTY-INCH BAND-SAWING MACHINE

worked over near the back with a series of blows extending to the central portion; if convex, the hammering must be done near the toothed edge. The necessary side-clearance of a band-saw blade in the timber is obtained either by forcibly setting over each tooth alternately to right and left, so that the resulting cut is wider than the blade itself, this being termed *spring set*, or by *swaging* the points of the teeth—that is, applying pressure to the front of the teeth, so spreading them sufficiently to clear the blade in the cut. This is the *swage set*. The latter is not quite so smooth cutting as the spring set, but operates quickly.

Circular Saws. Circular saws have teeth of very diverse types, the shapes of which depend upon the class of cutting, whether with or across the grain, and the relative hardness or softness of the timber. For ripping soft woods the teeth are spaced widely, and are formed more acutely than for the harder varieties. Figure **26** illustrates some of the commoner shapes of circular-saw teeth in use. A, B, and C are triangular teeth, with more or less rake, for softer woods; D has gulleted teeth, which afford great freedom for the sawdust. Two other shapes for ripping are shown at E and F. G is for ripping hard wood, the rake being lessened accordingly. Cross-cutting requires a different form of teeth, because, instead of passing down and forcing the fibres asunder, as with ripping, the saw has to sever the fibres at right angles, which imposes much more resistance. The shape of the tooth is that of an equilateral triangle, called a *peg* tooth, H, and it is bevelled to produce a keen edge, each tooth having the bevel facing in an opposite direction to that of the adjacent tooth. There is no hard and fast rule for the use of the peg-tooth, since some of the other previous shapes of teeth, notably D, are used freely for cross-cutting in the soft woods, but they are limited to these woods.

Inserted Teeth. The Americans have developed a class of circular saws with *inserted* teeth, which are used largely for diameters above about twelve inches. The advantages claimed are that a better class of tooth can be produced, as regards temper and clearance, than when the teeth are formed out of the solid plate, and also that in the event of nails or spikes being encountered in the timber, the damage to the saw is far less, because at the worst a few teeth are broken off or torn out without damaging the plate, and can be quickly replaced with new ones. But a solid-tooth saw under the same circumstances may have several teeth broken out, necessitating the reduction of the entire diameter to bring it down sufficiently to make a new set of teeth all around. The fitting in of the tooth is effected by vee edges, which prevent lateral movement, and the actual cutting portion or *bit* [A, **27**] is secured by a *shank*, B, the two wedging together firmly when slipped into place by the help of a special wrench, having a pin fitting in the hole in B. The shank is split in some cases to produce a decided spring, to retain the parts in place [**28**].

Special Saws. *Ground-off*, or *bevelled*, or *swaged* saws are tapered off in thickness from the centre to the edge, which may be very thin, while still leaving the body stiff. The grinding off is done only on one side. The result of thinning the saw thus is to save wood in the kerf, and to enable fine sawing to be done, so that these ground-offs are very suitable for fine cabinet and box work. The teeth of swaged saws are pitched rather closely together, and are smaller than those of ordinary or *plate* circular saws.

Hollow-ground saws are a class which work without set, the clearance being provided by grinding each face tapering from the teeth to near the centre, where a parallel portion is left for the spindle collars to grip. As the teeth are wider than the blade behind them, there is no side-friction. These saws make a very smooth cut, and are used for the finer classes of work, including mitre cutting.

Grooving saws are hollow-ground saws, made of definite thicknesses to cut grooves, ranging from $\frac{1}{8}$ in. to 1 in., or more. They leave a smooth surface. The teeth are coarsely pitched for good clearance.

Drunken Saws. Another class of saw employed to cut grooves or tenons is the *drunken* or *wobble* saw. The blade is held in an oblique position, so that it wobbles while revolving, or alternately travels from one side to another, so that when fed into the wood a slot is cut out. Bevelled washers are employed in some fittings to cant the saw. Figure **29** illustrates a saw by the Carron Company, Carron, Stirlingshire which has a ball centre, A, upon which the saw, bolted to a socket, B, embracing the ball, may be moved to give any required inclination within its range. B has a stud fitting in an inclined groove cut inside in the surface of a washer, C. The whole arrangement is firmly clamped by the nut, shown dotted, at the end of the spindle, and the saw cannot alter its angle until this nut is slackened.

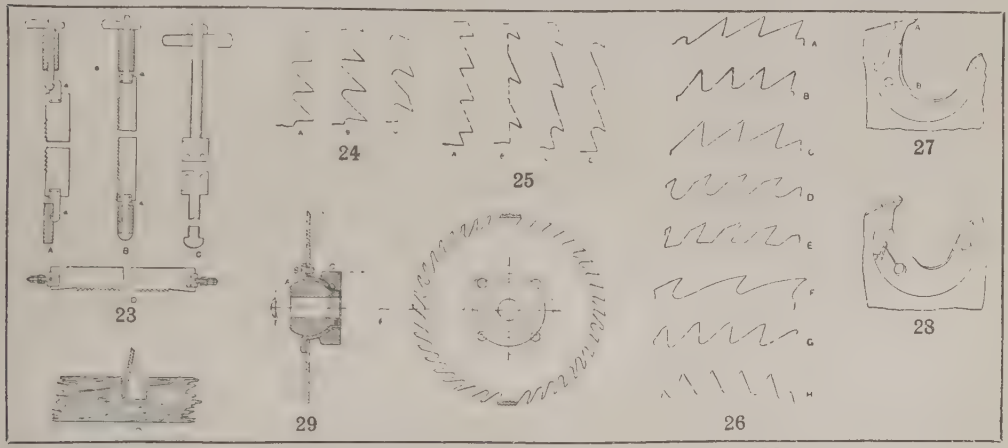
The diagram at D shows the action of the drunken blade in a groove.

A few other special saws may be mentioned, such as the *segmental* types, which have their blades built up of radial segments mounted on a central boss, by which device a thinner edge can be obtained than by using a solid plate. These are used for thin re-sawing work and fo. veneers. *Concave* saws are dished to form the envelope of a sphere, and are employed in cutting curved pieces, such as for wheel felloes and barrel parts. *Cylinder* saws, which are in the form of a large tube, with teeth on one end, saw out barrel staves to the correct curvature on one side.

Tension and Packing. The *hammering* of a circular saw is done to bring it into a proper condition for true running ; there may be tightness or *tension* at the rim or near the centre, according to the manner in which the hammering is done. The apparent rigidity of a saw plate disappears as it attains a high speed, and it becomes limp and pliable, and is very susceptible to lateral pressure. There is a certain critical speed for every saw, at which it will run true, if hammered

have occurred through sawyers getting their hands caught in the teeth, chiefly on account of the fingers slipping when feeding the stuff. One of the best-known guards is the "Ideal," constructed by Messrs. M. Glover & Co., of Leeds. It is so made that the saw is completely protected, no matter what the height of the wood being sawn.

Planing Machines. The *planing* machines constitute a large group, which operate by *cutters* or *knives*, either revolving or fixed. They true up narrow or broad surfaces, cutting on one or on several sides of the timber, and have hand or power feeds. The simplest class of planer is that represented in **31** (Messrs. John Sutcliffe & Son, Ltd., Halifax), termed a *hand* or *overhand*, or in America a *buzz*-planer. The frame carries bearings for a revolving spindle, which holds two or three long cutters revolving at a high speed, the spindle being driven from the belt pulley at one end. The timber is passed over the two tables projecting out at each end, and adjustable vertically upon sloping ways by screws and hand wheels. The fence on the right-hand table guides the wood in a straight line, and can be canted over for angular work.



23. FRAME SAWS **24.** FRAME-SAW TEETH **25.** BAND-SAW TEETH **26.** CIRCULAR-SAW TEETH
27 AND **28.** INSERTED CHISEL-POINT TEETH **29.** DRUNKEN SAW

accordingly, but if the speed is altered, or the saw becomes reduced in diameter through repeated sharpenings, in the course of time re-hammering is required. Another feature of great importance is the *packing*, which usually consists of hemp, plaited and packed in on each side of the plate, being supported by boxes or strips underneath the table. The object is to support the saw laterally, and enable it to stand up to the work without running out of truth, which it would do on encountering variations in the timber. There is another effect, that of imparting a certain amount of warmth to the saw plate, regulating the tension, and preventing buckling. The running of the saw can be controlled by packing harder or softer. Thus a saw that is "loose" on the rim may be made to run properly by packing rather tighter near the centre than towards the periphery, so that the central area is warmed up, and the metal expands more, pressing on the rim portion, and checking the unsteadiness. The packing is lubricated by some class of rather thin oil.

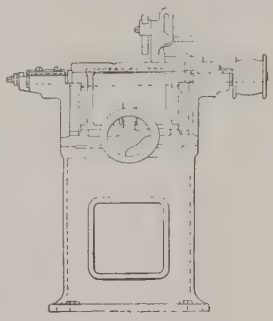
Saw Guards. The question of a provision of a *guard* to a circular saw has to be considered. It is a very dangerous tool, and many accidents

The two curved springs passing down the front keep the timber upon the table. In operation, the right-hand table is set lower than the left-hand one by the amount necessary for the cut, and the workman, standing alongside this right-hand table, passes the wood over it and the cutter spindle until the other table receives it. The machine is often termed a *jointer*, because one of its principal functions is that of preparing edges for glueing together. Planing out-of-wind, surfacing, chamfering, rebating, etc., can be done also, or, by putting in special cutter-blocks, mouldings and tongues and grooves can be produced.

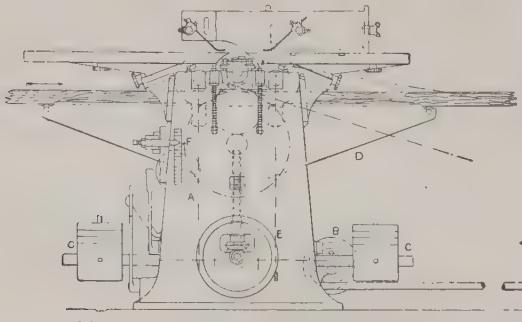
These planers are sometimes adapted to the requirements of wheelwrights by fitting curved guides at the front, to pass felloes over an extension of the cutter-block, and so to plane the inside to a regular curve. A boring and mortising attachment is also included when desired ; it is fitted similarly to that mentioned previously in connection with circular-saw benches.

The hand planer is one of the most dangerous machines to operate, because the knives revolve between the lips of the tables, and the attendant's fingers are very liable to slip into the opening

and become mangled. The safest class of work is that of shooting the edges of boards, in which case the hands are raised up to a considerable height from the knives. A safety guard, as applied to such planers, comprises a bridge spanning over the opening, its height being variable to suit the thickness of wood being planed, so that there is no chance of the workman's hands touching the cutters. If thin boards, etc., are being surfaced, the guard reaches across to the fence; but if edges are being planed, the guard is drawn away from the fence sufficiently to let the stuff pass, leaving the rest of the gap covered. The opening between the tables is made as narrow as possible in most machines by screwing thin tapered steel lips on to the table edges, projecting over the cutter-block as far as practicable.

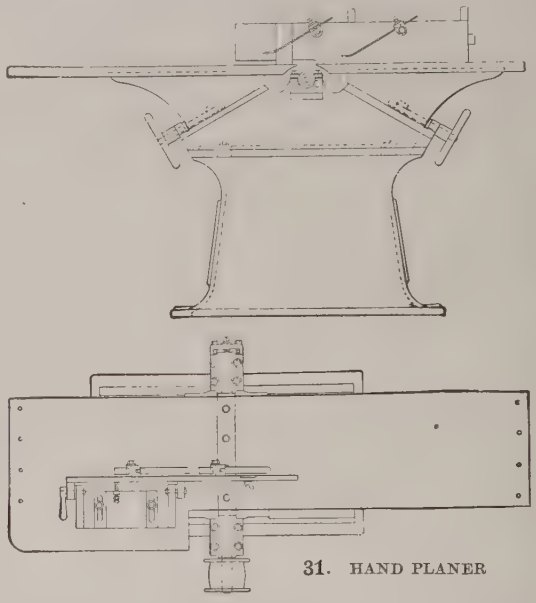


Surfacing and Thicknessing Machine. An advance on these machines is the combined surface planer and *thicknessing* machine [**30**], which has a power-feed by rollers, passing the timber through between the rollers and the cutters, and reducing it to an even thickness. One side of the stuff is previously trued upon the surfacer. The upper portion of the machine in **30** (by Messrs. McDowall) is formed like the preceding one; the arrangements for thicknessing include four serrated rollers, lying to right and left of the spindle, and passing the stuff between them, the upper rollers being positively driven by spur gears (the dotted circles of which are indicated), deriving various rates of speed from cone pulleys at A and B. Heavy adjustable weights at C, C, press upon levers which pull down the top rollers and enable them to get a bite on the wood. The table, D, supporting the latter, is raised or lowered by a vertical screw, operated by the hand wheel, E, and an index scale at F shows the thickness being planed. The arrows show the directions in which hand and power feed are given, these necessarily being in opposite directions, on account of working above and below the cutter-block respectively.



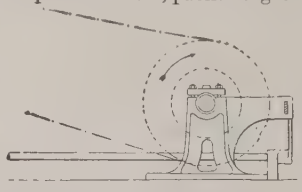
30. 15 IN. × 7½ IN. SURFACE PLANING AND THICKNESSING MACHINE

Trying-up Machines. Before describing other classes of planers which bear resemblances to those already illustrated, we have to notice a particular type of planer—the *trying-up* machine—which is adapted for truing up heavy pieces of timber. Such timbers are often too irregular and hard to pass through a roller feed with true results, so it is clamped to a travelling table and fed under the revolving cutters, leaving the planed face quite flat. The general form of the machine is represented in **32** (Messrs. A. Ransome & Co., Ltd., Newark-on-Trent), which shows the timber gripped on the travelling table, A, passing under the adze block at B (covered with a guard). The height of the adze block spindle is adjustable, by sliding it up or down the sloping housings, through hand, or belt, operating vertical screws. The driving of the spindle is by belt from the countershaft C, at the rear. The traverse of the table, with a quick return, is effected by belt pulleys behind the upright, actuating a train of spur gears, the last engaging with the rack on the under side of the table, A.



31. HAND PLANER

The machine is adapted not only for plain, large work, but can be used for truing and planing a large number of moderate sized pieces, such as the parts of doors, packed together on the table. Moulding and grooving can also be done by replacing the plain adze block with suitable cutters; and in machines provided with additional vertical side spindles, carrying cutter blocks, the edges of timber can be planed. A roller feed is fitted, when necessary, to the tables of trying-up machines for the continuous feeding of thin boards, which do not require to be clamped by the table dogs.



Panel Planers. The surface planing and thicknessing machines, or *panel* planers, which are used for all classes of boards and panels of moderate size, are constructed to pass the timber over a table, above which the cutter cylinder is revolving. The thickness is varied by altering the

height of this table. Another variety of these machines is the *two-side* or *double* surfacer, which has two cutter cylinders, one above and one below, so that a board or panel is finished at one operation.

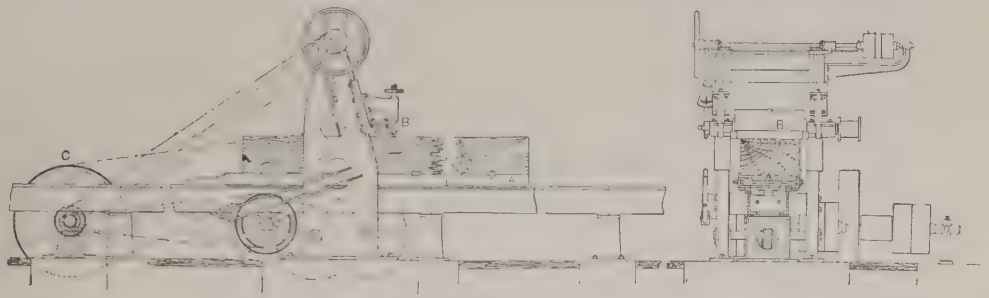
Four-cutter Planers. The most complete types of machines are those which work all four faces of the wood simultaneously—the *four-cutter* machines. These have the highest output, and a very good finish is imparted provided proper care is taken in working the machine. They embody a *fixed* knife in addition to revolving cutters, this knife giving a very smooth surface to the work. But as good results can be obtained only by feeding the stuff past the knife at a high rate, and as this demands great power, it is more convenient to use a fixed knife on one side of the wood only—the under side—working the other side and the edges with rotating cutters. In **33**, which gives a side elevation and end view of a 16 in. by 6 in. four-cutter machine for heavy work (A. Ransome & Co., Ltd.), the respective positions of the cutters are indicated at A, B, C, and D, these letters being put on the timber for clearness. The timber is fed in at the right-hand end, first by two pairs of large serrated rollers, driven by gearing, and weighted through balanced levers. On arriving at A, the wood is attacked by the bottom cutter block there, which trues the under side. Passing on to B, the fixed knife is encountered, this finishing the under side. A series of pressure rollers is placed above A and B, each roller being provided with an independent weight, so that any irregularity is accommodated. Other large feeding rollers at the centre of the machine continue to carry the timber on and past vertical cutter blocks at C, which plane or mould the edges, weighted pressure rollers keeping the wood down at this point. Finally, another horizontal adze block is met at D, finishing the top face. By means of the hand wheel, E, the operator can raise or lower the whole of the top feed rollers at once for timber of different thicknesses.

The fixed knife at B is rapidly dulled by its work, notwithstanding that the block at A has roughed off the outside of the timber, and it is therefore fixed in a removable drawer, that can be pulled out and changed rapidly. The fixed knife cannot be applied successfully to cutting hard woods. It is set angularly across the machine to give a shearing cut, and the pressure rollers above it are placed to correspond. An extra cutter spindle is sometimes added at the delivery end for *sticking* a light beading on the top of the plank or board. A *shavings cutter* is a useful adjunct to a machine having a fixed knife; it comprises a hopper containing revolving cutters, which cut up the long shavings into short portions, that can be readily sucked up by a pneumatic exhausting system.

Rapid Planers. The *lightning* or *rapid* planers are a special class, using a fixed knife only. The work is carried over it by a large roller covered with indiarubber, and the rate of feed is very high. The class of planing done is that on box boards, lap boards, blind laths, which are light, and which require only a thin shaving off to produce a highly finished surface.

Four-cutter Moulders. Four-cutter machines, designed for producing mouldings only, resemble the planers in many respects, but the fixed knife is not used. A good idea of a moulder can be obtained from the drawing [35] (John Sutcliffe & Son, Ltd., Halifax), showing a 16 in. by 4 in. machine in elevation, plan, and end view. The cutter block spindles are at A, B, and C for bottom, edges, and top respectively. The fluted feed rollers, situated under covers at D, can be driven at any of six different rates, from 18 ft. to 70 ft. per minute of feed, the variations being produced by sliding spur gears, as seen. The wood is held firmly to the cutters by weighted *pressures*, which can be adjusted to suit requirements. Combined planing and moulding machines are employed for either class of work, as desired.

The spindles of planing and moulding machines run at from 4500 to 5500 revolutions per minute, and the cutters must be very accurately balanced in order to produce true work and to avoid damage to the machine through irregular running. The bearings must also be good, with ample surface, and making a close fit without shake, which is fatal to accurate results in planing or moulding.

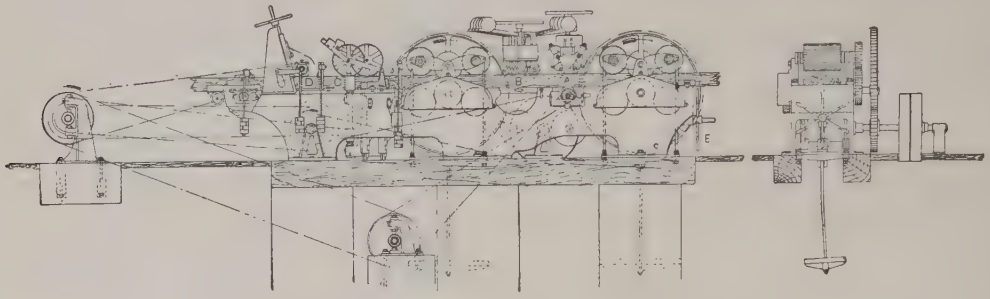


32. 20-IN. TRYING-UP MACHINE

Vertical Shaper. The *vertical* spindle moulding machine, or *shaper*, has either one or two spindles, projecting up through a table, on which the work is laid. The spindle carries a moulding iron, and as the work is traversed past it cuts the surface into a form corresponding with that of the iron. A fence guides the wood in a straight line. Figure **34** shows a double-spindle machine by Messrs. Thomas White & Sons, Paisley, from which it is seen that the spindles, A, A, have long pulleys driven by half-twist belts from the countershaft. Each headstock carrying its spindle is adjustable up and down in slides, the adjustment being obtainable by turning the hand wheels at the front. The treadle in front, near the ground, enables the operator to start and stop the machine by slipping the belt on the fast and loose pulleys at the countershaft. Concentric rings are fitted into the table around the spindles, to allow of putting on differently sized cutters. The object in having two spindles is to enable curvilinear work to be done expeditiously, by using one or other of the spindles, which revolve

in opposite directions, according to the way which the grain runs; otherwise, clean work cannot be ensured. If the machine has only one spindle, that has to be reversed, and a different cutter block also put on, or else doubled-edged cutters are used. The working of curves is effected by using a template of the correct outline, placed beneath the moulding, and bearing against a ring encircling the shaper spindle. The template can often be dispensed with and the moulding alone brought into contact with the guide-ring, or collar. It is best simplest of which are those for plane surfaces, having flat knives bolted to the sides of a cylinder or block in the manner shown in **57** [page 4245], the length ranging from a few inches to two or three feet. Moulding cutters are also made as shown at **56** on that page.

The vertical spindle-moulding machines uses a variety of cutters. In the *French* or slotted spindle a thin steel blade is fixed in a slot in the spindle end, and, its edge being formed to correct outline, it is turned over forcibly like a scrape to produce



33. FOUR-CUTTER PLANING MACHINE

to fit a guard over the revolving cutter, as a protection to the operator. A cage made of strips, or of netting, completely covers in the top and the sides as far down as the work will allow. There is then no risk of the workman getting his fingers caught through the wood slipping.

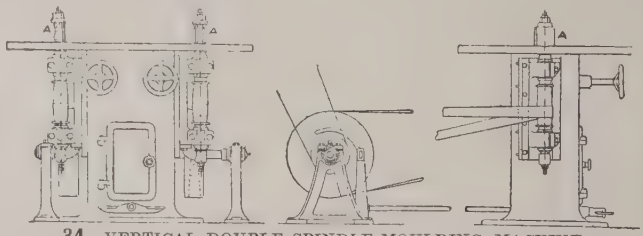
A special attachment for cutting dovetails is often fitted to these shapers, comprising a clamp, which holds the wood vertically, and presents it to the dovetail cutter on the end of the spindle. The pitch of the dovetails is determined by a template plate, having notches which lock the clamp at definite positions while the cutter is at work.

Another class of moulding machine, which possesses a greater range than the foregoing, is made with an overhanging arm supporting a vertical spindle, below which a large table is located. In this design the work can be passed *under* the tool, and operations be done on the central portions of a board or panel, such as raising or recessing various patterns, cutting grooves or trenches, in string boards for stairs and shelves. The table can be moved about freely, and is fitted with fences.

In the most complete machines a vertical shaping spindle is included, projecting up through the table, by which ordinary mouldings can be worked. The term *variety* moulding machine is commonly applied to this class.

General Joiner. The *general joiner*, or *universal* joiner, or *complete* joiner, is a combination machine of great utility in situations where a number of separate machines cannot be installed. It combines a circular saw, with rising and falling spindle, with which sawing, tonguing, grooving, and rebating can be done; a band-saw apparatus, a four-side planing and moulding apparatus, a vertical spindle for circular moulding, and a tenoning apparatus. Boring may be done also by attaching a bit to the tenoning spindle.

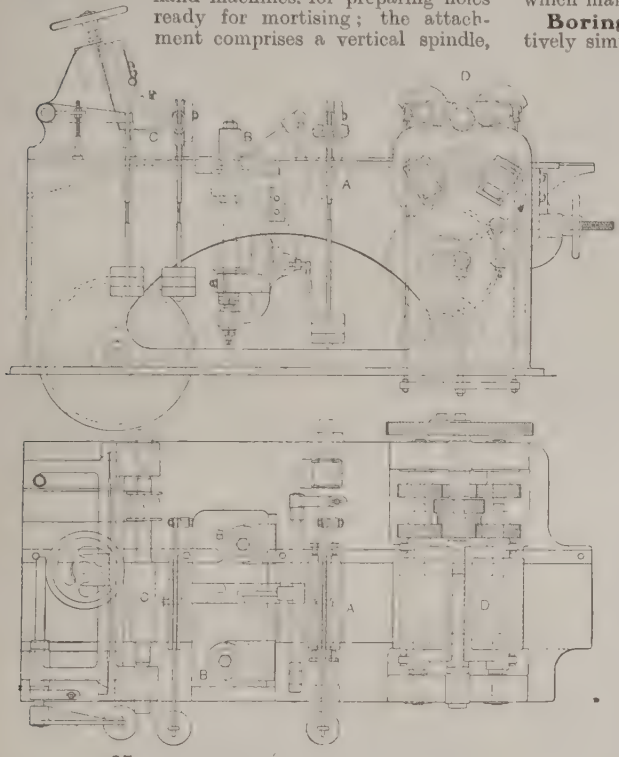
The cutters and cutter-blocks employed in the planing and moulding machines described in the previous article embody numerous shapes, the a working edge. The French cutters are used chiefly for special classes of work, as the blades can be made cheaply and quickly. A common method is to fit flat cutters between grooved collars, as illustrated in **34**. Sometimes also an ordinary square block is fixed to the spindle end, to receive flat moulding cutters. Solid cutters bear some resemblance to milling cutters for metal, in having the moulded outline formed on the circumference. Sharpening is done on the flat between the teeth. The non-reversible types have a clearance in one direction [**36**]; the reversible class are flatter on the periphery [**37**], so that either edge may come into operation as the machine spindle is reversed. Four, eight, or ten cutting edges are produced, according to whether the cutters have two, four, or five teeth [see **58**, page 4245]. Figs. **38** and **39** illustrate their application, the first showing the use of the work itself to press against the guide collar under the cutter, the second that of a separate pattern plate to which the moulding is attached.



34. VERTICAL DOUBLE SPINDLE-MOULDING MACHINE

Mortising Machines. These, which are intended for cutting the slots or mortises in timber, are of vertical or horizontal types, the latter chiefly for light work. The commonest method is to use a chisel [**40**], resembling a hand mortising chisel, but held in a spindle, and fed down by hand or power. An improved form in general use is the *self-coring* type [**41**], which has two projecting lips, which, being tapered inside, have the effect of drawing the chips from the mortise at each stroke, thus keeping the hole clear. Figure **42** shows a

plain hand mortising machine, by the Carron Company, in which the timber is gripped in a vice by a hand wheel and screw upon an upper slide, which can be moved longitudinally by rack and hand wheel, and also laterally, while vertical adjustment is produced by the screw and hand wheel beneath the knee. The spindle, which fits within a sleeve sliding in a hexagon bearing, is reciprocated up and down by the long pivoted lever, counterbalanced to bring the spindle to the top of its stroke automatically. A handle and collar is fitted on the spindle, by means of which it can rapidly be reversed, to make the chisel face round in the opposite direction for finishing both ends of a mortise. A boring attachment is often fitted to hand machines, for preparing holes ready for mortising; the attachment comprises a vertical spindle, carrying an auger, revolved through bevel gears and handles.

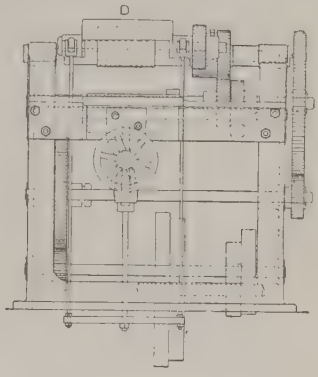


35. FOUR-CUTTER MOULDING MACHINE

A peculiar class of tool used for mortising comprises a combination of an auger and a chisel, the former revolving inside the latter, and clearing out the centre of the hole, while the square corners of the chisel finish the angles. This, the *hollow* chisel [43], is used in both vertical and horizontal machines, and is very rapid and neat in its action. The auger, which has a support near the cutting edges of the chisel, draws the chips out of the hole and away through the openings in the side of the chisel. Another remarkable style is the *chain* mortiser, which runs an endless pitch-chain around a sprocket wheel and a plain roller, while the back is supported by a flat bar. Each link of the chain has a tooth formed on it [44], so that as the chain travels it cuts a slot equal to its width. The rate of movement is about 1500 ft. per minute. The chips are drawn out of the mortise on the rising side of the chain. The work is done with great rapidity, and the tendency to split the wood is not nearly so marked as is the case with a reciprocating tool.

Tenoning Machines. Tenoning is performed by cutter blocks or by tenoning irons. The first-named operate laterally, and the machines which use them have two spindles, above and below the timber, both driven from a single belt, which is provided with a tightening jockey pulley. The cutter or adze blocks have their irons set on the skew, and have provision for cutting the shoulders on the timber. The timber is clamped to a carriage which runs by rollers on cross-rails. In cutting double tenons, a vertical spindle is required on the machine to carry a drunken saw, or a narrow cutter-block, which makes the centre cut.

Boring Machines. These are comparatively simple in construction. Spindles are single or multiple; the plainest class is the wall or pillar machine, which consists of a framing supporting a spindle, a sleeve, mitre gears, belt pulleys, and a lever arrangement for feeding. The self-contained machines include a pillar, on the front face of which the table is adjustable up and down to suit the thickness of the work. The multiple spindle machines embody a number of spindles, each holding a different-sized auger, so that any size hole within the range can be bored without the trouble of changing tools. The railway carriage and waggon shops especially favour these machines for boring the heavy framings. In some instances the spindles may be angled for boring sloping holes. Horizontal boring machines are used to much less extent than vertical ones, being chiefly designed for small work, such as boring dowel holes in the edges of boards. The augers used in the machines described are of the usual twist types, some of which are illustrated in **41** on page 4245.



Dovetailing Machines. Dovetails are usually cut by revolving cutters, having two lips, and a body the form of which corresponds to the tapered outline of the dovetail. In the single spindle machines the timber is clamped and moved along in definite stages, controlled by a slotted driving plate matching the pitch of the dovetails. But a much greater output can be secured by increasing the number of spindles, to cut all the dovetails in one side of a board at one traverse.

Corner locking is practised very largely in place of dovetailing, and consists in forming rectangular teeth which interlock and hold very firmly. As the form

of cut lends itself to very rapid output, a good deal of box and case work is now corner-locked instead of dovetailed. The machines employed have a table on which the work, which may include a pile of boards, is clamped, and a revolving spindle holding a number of narrow cutters attacks the edges and cuts out the series of notches.

Lathes. An ordinary turning lathe is illustrated in **45**. Here we only concern ourselves with special types, which are designed for repetition work. The *Blanchard* or *copying* lathe produces objects of regular or irregular shape from a pattern or copy. Gun-stocks, spokes, hammer-handles, boot-lasts, brush-handles, etc., are among the chief pieces turned out. The principle is that of rotating the copy and the work, and causing a roller to press against the copy, thus coercing a rocking rest which carries a revolving cutter head in contact with the wood. The contour of the copy is therefore reproduced on the work.

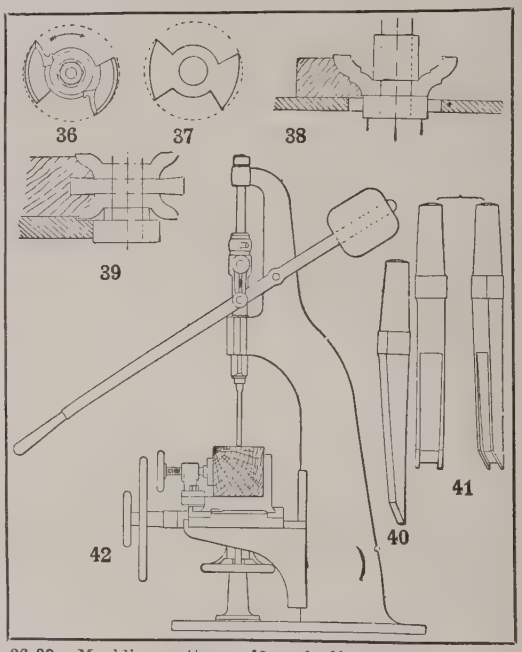
Back-knife lathes are a class for producing circular work of varied contour, such as chair and table legs, balusters, etc. The tools are held in a rest, and controlled by a pattern; the back knife is held in a frame in a sloping fashion, and the movements of the slide-rest and the knife are timed so that the latter comes down the back of the work and finishes it to correct outline as the roughing tool passes along.

The *rounding* machines perform a plain class of turning by very simple means, comprising a revolving mandrel carrying a cutter, which acts on the stuff, which is simply slid through.

Sandpapering Machines. These include the use of drums, discs, and belts, each suited to particular classes of work. The belts are run over pulleys, which can be drawn apart to give the required tension. Articles having curved outlines are treated on the belts, which give to the conformation and enable curves and hollows to be treated. The drum machines are of two types—one with a flat table, over which the work is passed, touching the drum surface; an exhaust fan removes the dust as fast as it is created. The other drum type has three drums, over which the wood is passed by eight geared feed rolls. Each drum has a side oscillating motion to prevent the formation of scratches. Small sanders with vertical spindles are constructed on the lines of the vertical shapers. Disc sanders resemble the disc grinders used by metal-workers, and the work is presented upon a table to the disc. For large areas the *flexible* arm machine is of great value. The sandpaper is strained over a wooden disc, supported at the end of an articulated frame, which, by virtue of its jointing, can be brought anywhere over a large table.

Wood-turning. The craft of wood-turning is very ancient. It was formerly done by a reciprocating mandrel, operated by a bow and cord; or by an overhead spring pole, operated by a treadle. The bow and cord still survive in the East. All modern wood-turning lathes are fitted with continuously running mandrels. Lathes for woodwork are much plainer than those for metal turning, seldom comprising more than a plain ungeared headstock, a simple poppet, and a hand tee-rest. For some engineers' pattern turning, a plain slide rest is fitted and a large face-plate, or a special face lathe. But with these exceptions, and that of the ornamental turner, wood-turners' lathes have no aids to supplement the work of the hands. The fact is, a skilful turner is more nearly independent of his lathe and tools than most craftsmen, and excellent work is done by such men on lathes that would excite the derision of the engineer or the wealthy amateur. Wood-turning is one of the crafts in which manipulation is the supreme factor, one in which the essential tools are few and very simple in character.

A large, high-class lathe, much superior to those usually found in wood-turners' shops, is shown in **45**, made by T. White & Sons, of Paisley. It is all of iron, while wood figures largely in much lathe construction. It is of large size, 12-in. centre, designed for pattern turning and general utility. The following are the principal parts: the *bed*, A, having at one end the *headstock*, B, with the four-stepped cones, C, turned inside and out for perfect balance, and driven from the cones, D, on the



36-39. Moulding cutters **40** and **41**. Mortising chisels **42**. Hand mortising machine

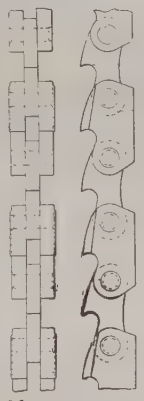
countershaft, fitted with fast and loose pulleys. E is an iron *face-plate*, to which work can be screwed directly, or through an intermediary plate of wood. F is the *fork*, or *prong* centre. G is the *loose poppet*, or back poppet, or movable poppet, or loose head, and its centre is the *back* centre. It is fitted for turning long tapers, as on columns, by utilising the cross-traverse movement provided. The tool rest commonly used is the *tee-rest*, H, with which nine-tenths of woodwork is done. But for long pieces, a *slide-rest*, J, is provided, comprising the tool holder on a cross slide, adjustable across the top of the saddle, which is fitted to the bed with vee'd edges, and an adjustable strip. The saddle is travelled up and down the bed by a rack, K, the pinion of which, L, is actuated through a pair of gears, N and O, by the lower lever handle, M, the upper handle being for the cross traverse. A nest of drawers, P, is formed underneath the bed to receive the tools, and a rack, Q, adjacent, receives face-plates. R is the *back board* for tools in use.

Wood-turning Tools. The principal operations are performed with two tools only, the *gouge* [**50**] and the *chisel* [**51**], each being used in three o

four different sizes. Both are true cutting tools, both require practice and skill in their manipulation, and all conceivable shapes are outlined by deft handling of these two. True, there are many others which complete a turner's kit, but they are only used for occasional finishing, smoothing, and correcting. All the roughing out, and by far the greater portion of the finishing also, are done by these two very simple tools. We will consider them and their work in turn.

The Gouge. This [50] is like no other gouge. It has a considerable convexity of the cutting edge, the reason of which is to prevent, or to lessen, risk of hitching or catching of the revolving work against one corner of the tool, which would happen if an ordinary firmer gouge were used for turning, or if the gouge were ground like 46, instead of like 47. It is this rapid revolution of the work, with the centrifugal action, tending to knock the gouge away, that the turner, consciously, or instinctively, born of habit, always has to bear in mind. The beginner, after sundry hitchings, and damage to the work, his hands, or the tool, or all in unison, soon learns to present the gouge warily. The thing to remember is not to allow the work to catch in the sides of the gouge, but to do the cutting at and near the point *a* only. Bearing this in mind, faces that are perpendicular to the axis of rotation can be roughed down safely, the back of the gouge being held next the face being cut. Concave and convex portions are also easily cut, the back of the gouge always lying next the face being turned.

43. HOLLOW CHISEL



44. MORTISING CHAIN

When turning a parallel, or straight portion, the gouge can be held straight forward [52]; but, generally, more rapid reduction can be effected by turning with a diagonal cut, or sideways, changing the direction of cutting towards right and left alternately. Deeper cutting can be done by this device than by straightforward presentation, though the latter is suitable for taking finishing cuts. To suit details of work of different dimensions, gouges are made in different sizes, from $\frac{1}{4}$ in. to $1\frac{1}{4}$ in., so that either fine details or heavy roughing down can be done by selecting suitable gouges. The *handles* of these gouges [49 and 52] will be noted as being characterised by much leverage. To this, in fact, they owe so much of their value. The workman is thus able to control their movements in opposition to the severe stresses caused by the revolution of the work. A firm grip is taken at the fulcrum—that is, the place where the gouge lies on the rest [52]. The gouge is gripped there between the forefinger and thumb of the left hand, while the end of the handle, gripped in the right hand, is kept in constant movement in arcs of circles to suit the nature of the cutting being done. In some cases the side of the gouge is presented, as in taking a finishing cut in a bore [49]; 53 is a gouge used on the slide rest.

The Chisel. This [51] is the only turning chisel with a doubly bevelled edge like that of the axe, though used in quite a different manner. It is presented and traversed against the revolving work, cutting shavings at and near the obtuse-angled end. The degree of pressure exercised is controlled by the hands of the workman. The tool is gripped on the rest [59] by the forefinger and thumb of the left hand, similarly to the gouge while the right manipulates the handle. Like the gouge, the chisel will turn straight and convex portions, though not concave ones, unless of large radius. The point to observe is that cutting must not be done far away from the point, *a* [48], and, say, over one-third of the width from the point, otherwise the tool is liable to be caught, and damage the work. It can be used indifferently in right and left directions [55]. The chisel, like the gouge, if used properly, leaves a very smooth surface. The acute-angled corner of the chisel fulfils the special function of cutting down perpendicular or nearly perpendicular faces [58], and of severance. Being so keen a wedge, it will cut deeply and rapidly, leaving the smoothest face. It cannot be used for turning like the other angled corner, but would be caught by the work if presented thus.

Scraping Tools. Though the gouge and chisel are the sheet anchors of the turner, it is obvious that they cannot cover all details of work, and especially in pieces of large dimensions. Thus, a disc on the face-plate cannot be turned and finished with the side chisel. For this a *firmer* chisel, acting as a scrape, must be used. A deep hole can be roughed with the gouge, and partly smoothed with the keen edge of the side chisel, but a true, smooth face must be finished with a *side tool*. A concave portion can be roughed with the gouge, and is often finished with it; but frequently it is finished with a *round nose*, especially in work of large diameter. These and some other tools act by scraping only. Hence, as scraping roughens up the grain, the object always sought is to do as much preliminary work as possible with the gouge, and take the merest film off with the scraping tools.

Hard and Soft Woods. The relative utilities of scraping differ in the practice of turning hard and soft woods. It is done much more extensively in the first named than in the second. The reason is that the grain of hard wood does not become roughened up nearly so much at that of soft timbers. This, of course, is not an argument in favour of scraping, when turning can be done by the gouge and chisel. But when work is of a highly ornamental character, and of large dimensions, as in much of that done on the face-plate, the risks of hitching are lessened by the use of scraping tools. The harder the wood, the more nearly the conditions approach to the turning of the softer metals. Thus, Spanish mahogany is harder than baywood, and lignum vitæ or box is more suitably scraped than beech or birch. Also, dry, well-seasoned woods can be more readily scraped than moist and spongy stuff. So that there is room for exercise of judgment. When details have to be turned to exact dimensions the scrapes are valuable aids, because very minute amounts can be removed by their assistance, and further finishing may be avoided.

The hardwood turners, therefore, have a large assortment of scrapes for turning concave and convex portions, for recessed work, right and left handed, besides special forms of tools for internal shoulderings, etc., in some of which it would be quite impossible to use the turning gouge or chisel.

All turned work may be classified under two heads —that done *between centres* and *chuck work*.

Work between Centres. This signifies that the piece to be turned is supported and revolved between the fast headstock and the loose poppet. It includes all pieces the length of which exceeds the diameter by so much as to require support besides that afforded by the headstock. Generally, such pieces are held and rotated by the fork or prong centre [**51**]. This is interchangeable with other chucks on the mandrel nose. It derives its name from its fork or prong like character. The end of the wood, if soft, is driven against it, or, in hard wood, a saw kerf is often made to receive it. The back poppet centre is entered readily by screwing up the mandrel slightly. Occasionally other chucks are used to drive work between centres, but in most instances the fork is employed; **65** shows a piece of wood roughed out with the axe preliminary to turning.

Chuck Work. This signifies that pieces are held at the headstock end only, and without other support. Pieces the length of which does not greatly exceed the diameter or which are of less thickness are turned thus.

Face-plates. These are the principal chucks. They differ from those for metal turning in their greater simplicity, comprising only two forms, in a range of dimensions. One is the *screw point chuck* [**57**]—that is, the work is held on it by a central, short, tapered screw, having a coarse thread. This is sufficient to hold a small piece of wood—say, not exceeding 4 in. or 5 in. in diameter. Thick blocks —say, above 3 in. or 4 in. diameter—are generally secured in addition with a couple or three wood screws put in from the back of the plate.

Large Face-plates. These [**60**] have countersunk holes for the attachment of work by wood screws inserted from the backs of the plate. They are made in as large a range as the capacity of the lathe will admit. For very large face work, lathes are made either with a deep gap in front of the headstock, or the headstock is made to turn round through 90° or 180°, so that work can be taken as far down as the floor. In such cases a special rest is rigged up on a heavy *floor stand*, sufficiently massive to remain steady under the stress of turning. In many cases the trouble of reversing the headstock is avoided by carrying the mandrel out at the rear to hold the large face-plate, so that it is always ready for use. Pattern-makers, as well as wood-turners, use these face lathes for wheel-work of all kinds.

Wooden Plates. The face-plates are made of iron, except in the very small sizes—say, under 4 in.—for which brass is commonly used. But a large proportion of turners' work, and much the largest in pattern turning, is done not on the metal plates directly, but against an intermediary plate of wood screwed to the metal. The advantages are these: The wood plate can be faced up truly, while the metal plates often run slightly out of truth, due to wear on the thread. Turning can be done right up against the wood without inflicting damage on the tool edges. There is a slight elasticity in the wood, noticeable when turning, by comparison with turning done close down to the iron. But the principal advantage is that the wooden plates can be recessed to receive work for re-chucking centrally, often, too, without using screws, the friction of the work in its recess—or over a check standing out, in the case of chucking by a hole—being sufficient to retain it in place for light turning. In time, as a face-plate becomes turned down thus, a new one is substituted. Small plates are made of solid stuff, but those over 12 in. to 18 in. diameter are built up, the plainest with patterns, the largest with a cross and diagonals [**56**]. Much work is chucked, not directly on the plate, but blockings screwed to it. The reason is that plates of several feet in diameter are rather expensive, and would soon wear out if frequently recessed. The face is therefore retained plane, and chuckings are done on temporary blocks screwed to the face. This is done in large gear wheels, pulleys, and various rings.

There are some classes of turned work in which it is undesirable or inconvenient to insert screws, yet which must lie against a flat face-plate. Then *paper joints* are useful. These are adopted extensively in pattern turning, and it is surprising how great a mass paper will hold. Newspaper is suitable. It is glued on both sides, one side going next the plate, the other receiving the work. On large pieces, narrow strips of paper at intervals are sufficient; pieces of a few inches diameter may be carried with one piece of the same diameter. The joint is broken after turning by lifting the work with a chisel inserted in the joint, when the paper splits in two.

The Bell Chuck. The bell chuck is termed the *cup chuck* [**61**], and is used for some classes of work too small or too long for the face-plate, and also for pieces which have to be bored, or for objects that have to be turned and cut off in succession [**61**]. Boxes, egg-cups, vases, are examples of the first; drawer-knobs and cord-pulleys of the second. The wood is driven into the cup and holds by friction alone. The chuck is usually of brass.

There are many very delicate objects which will not bear any driving into the bell chuck, or into a wooden chuck driven into the bell, and recessed to receive work. For such objects the *spring chucks* are valuable. These are made generally in a hard wood, box being the best; sometimes also in brass. The body of the chuck, slightly tapered outside to receive a ring, is split by several saw kerfs cut radially nearly to the bottom of the chuck, and the metal ferrule is made to compress the body round the work by tightening it down the tapered body. Turners make these in several diameters.

Methods of Measuring. The diameters of turned work are mostly taken with common calipers. When large numbers of similar pieces have to be done the calipers are often fixed with a thumbscrew. A sizing tool [**62**] is also used with a guide at the back, for repetition parallel turning.

Dimensions in the longitudinal direction may be taken with a rule; but when quantities are done a strip is generally used, having the various lengths marked across it, whence they are transferred to the work. In such cases the piece is roughed out approximately parallel to the largest diameters, and the lengths set off on the rotating piece. Then these are set in with the keen angle of the side chisel down to the various diameters, which are turned, and checked by the calipers. Every portion is first turned as a parallel section, after which the different moulding sections are shaped with the gouge and other tools. Compare **63** and **64**.

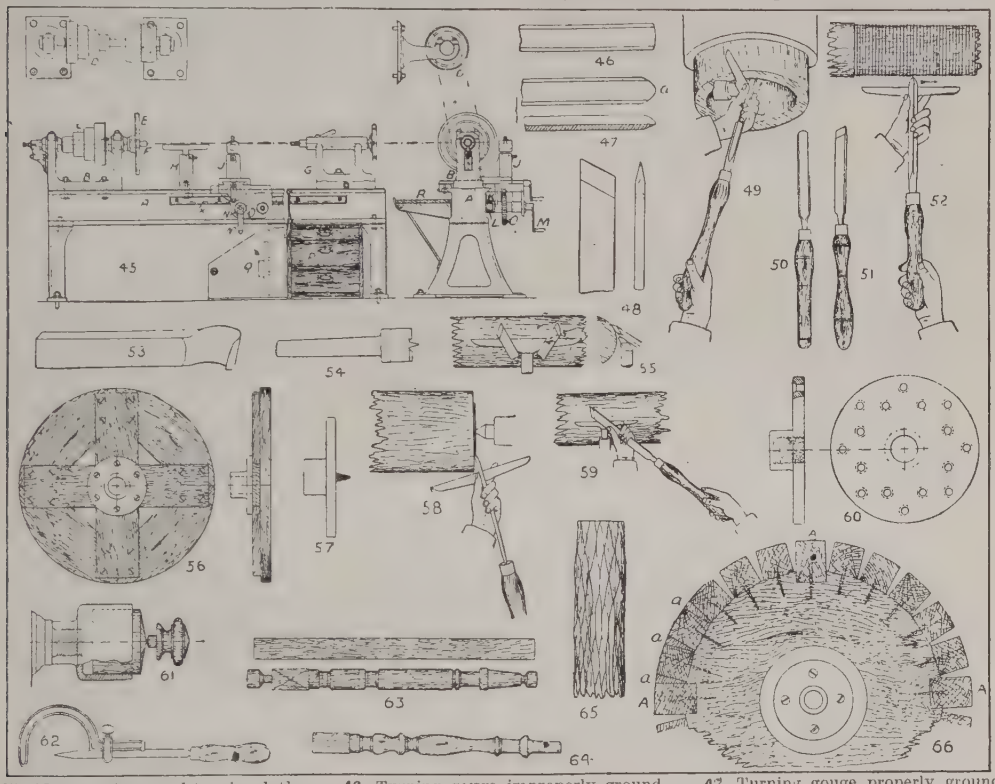
Templets. These afford much aid to calipers in repetitive work. They are cut from a thin strip of wood and tried upon the work [**63**] from time to time as the final corrections are being made. A little chalk or red lead may be rubbed on the edge, to indicate the localities where contact takes place.

Straight Shafts. When a long portion of turned work is to be perfectly straight, as in the shafts of columns and pillars, and in pattern pipe-

turning, much time may be saved by first turning down at each end and in the centre to the correct diameter, and then planing a flat along from end to end, forming a tangent to the diameters. This, being chalked or red-leaded, becomes a guide to rapid reduction of all the intermediate portions, which can be turned almost to size without stopping the lathe. It is then easy to finish with a side chisel, and correct, finally, with a firmer chisel.

Steadies. When long, slender pieces are being turned between centres, they wobble, and cannot be turned truly without support intermediate with the centres. These steadies are very plain by comparison with those used by metal turners. Sometimes a rigid rod only is wedged between the ways of the bed, to be kept in contact with the back of the work; but generally a block of wood or an iron bracket is bolted to the bed to carry either a vee-block or to receive semicircular blocks. A single vee-block will cover a moderate range of diameters, but semicircular blocks will fit only one side. The practice is to turn down a portion to the correct size, somewhere about the centre of the length; grip that with the steady blocks, and then proceed with the remainder of the turning. In very flimsy work the steady is shifted to two or three successive positions, or more than one steady is used. Lubrication is necessary, or the friction between the work and the steady will cause smoking, and char the wood. If a lathe has a slide-rest, then a travelling steady which follows the work behind the tool can be used.

Square Turning. The principle of this is illustrated in **66**. The articles to be turned are arranged round the periphery of two or more discs, which are driven between the centres, driving with a face-plate at one end attached to its disc, the other end being supported on the back centre. The pieces of wood are attached with screws, the lengths being in excess of the finished article, to allow of the portion with the holes to be cut off subsequently. It is not necessary to fill in the spaces between the pieces with a view to prevent breaking out of the grain by turning, but those who are not skilful in the use of the tools glue strips in, as shown at *a* in **66**. The blocks, A, in the illustration are simply distance pieces, by which the end discs are retained rigidly. Of course, the larger the diameter of the ends, the less will the slight curvature due to the radius be in amount, and generally such ends would have to be framed up with a cross and segments. After the faces have been turned corresponding with one position of the articles, they are turned round and rescrewed in successive fresh positions.



45. 12-in. centre wood-turning lathe **46.** Turning gouge improperly ground **47.** Turning gouge properly ground **48.** Turning chisel **49.** Finishing with gouge in hole **50.** Turning gouge **51.** Turning chisel **52.** Method of holding gouge **53.** Slide-rest roughing tool **54.** Fork or prong centre **55.** Side chisel applied right and left hand **56.** Built-up wooden face-plate **57.** Screw-point chuck **58.** Side chisel cutting down an end **59.** Method of holding chisel **60.** Large face-plate **61.** Piece of work in cup chuck **62.** Sizing tool **63** and **64.** Article roughed out and finished **65.** Wood roughed for turning. **66.** Square turning

Ornamental Objects. The work of the geometrical turner requires special high-class chucks and a special lathe. But very beautiful, effective ornamentation can be produced by the plain wood-turner by the repetition of similar figures, such as those shown in **63** and **64**, and allied forms, for there is no limit to the possible combinations of curves and straight lines.

J. G. HORNER

A STATION FROM WHICH WIRELESS MESSAGES ARE SENT ACROSS THE ATLANTIC

THE WIRELESS TELEGRAPH STATION OF THE MARCONI COMPANY AT CLIFDEN GALWAY

The Receiving Apparatus and Aerial. Detection of Signals. Detectors. Einthoven Galvanometer. Brown Relay. Portable Sets. Wireless Compass.

RECEIVING STATIONS

In the previous chapter methods were described of producing the electromagnetic waves which travel outwards from the aerial or antenna, and form the means of establishing communication. We have now to see how these waves are intercepted at the receiving station, and to deal with the various parts of apparatus essential to "picking up" the signals.

Resonance. How a receiving circuit will respond to a transmitting circuit can be seen from the experiment represented diagramatically in **15**. Here L_1 is a Leyden jar excited by an induction coil, so that sparks cross the gap, G, and L_2 is a similar Leyden jar, the inner and outer coatings of which are connected by wires, the contact of which can be varied at K. When the capacity and self-induction ($L \times C$) of the Leyden jar L_1 circuit setting up the waves is the same as that of the jar L_2 circuit (the *tuning* being effected by sliding K up and down until the self-induction of the wire and the capacity of L_2 is the same), a responsive spark will fly across a gap, F, made between the outer coating of L_2 and a piece of tin-foil, T, nearly touching it and connected with the inner coating. In other words, when the two circuits, sending and receiving, are in resonance, electromagnetic waves sent out from L_1 will excite oscillations in L_2 and cause a spark at F.

The Receiving Apparatus. In actual practice the current produced in the receiving circuit is infinitesimal, and instead of producing a spark it is made to excite a detector, which is described later. It will be convenient if we first study a simple receiving apparatus, shown in diagram form in **16**.

A represents, as usual, the aerial or antenna, and E the earth. They are connected by a coil of thin wire, J_1, acting as the primary of a very small induction coil, which induces an oscillating current in the secondary coil, J_2. This coil is placed in series with a condenser, K, and shunted on the condenser is the detecting device, D, and a sensitive telephone, T. If the circuit comprising aerial, coil J_1, and earth has the same capacity and inductance ($L \times C$), or a simple multiple or sub-multiple of the capacity and inductance of the transmitting circuit, it will be in resonance with it; and when the electromagnetic waves reach the aerial, oscillations will be set up in this circuit, which will induce oscillations in the secondary circuit, including J_2 and K. These alternating currents will cause vibrations in the telephone, T, producing a buzzing sound audible to the ear.

The simplest form of receiver would be one in which the aerial was of exactly the same dimensions as that of the transmitting apparatus, but this, of course, would be impossible in general practice. Consequently, if the aerial is too short to be in resonance naturally with the transmitting circuit, we add to it a certain number of turns of wire represented by J_1. Sometimes it happens that the aerial is too long, and in such a case a condenser is placed between the aerial and earth at the point C, shown in **16**.

In the majority of amateur wireless stations a transformer is used consisting of one coil only, with sliding contacts, as shown in **17**. Here the turns of the tuning coil, *ab*, represent the primary of the small transformer, and the turns, *cb*, the secondary winding. A very small condenser, K, often termed a *blocking condenser*, is used, and on this is shunted the telephone, T; *a* and *c* are sliding contacts, so that the number of turns in both *ab* and *cb* can be varied in order to tune up the circuits. For not only must the capacity and inductance of the aerial and earth circuit respond to that of the transmitting circuit, but the capacity and inductance of the small secondary circuit represented as within the dotted line must respond to the aerial and earth circuit.

The Receiving Aerial. The receiving aerial is thus connected to the primary of the oscillation transformer or jigger, the other end of the jigger being connected to a plate buried in the earth. A good earth connection is very necessary; and although for small stations a domestic water-pipe usually answers the purpose, in large stations, as we noted in the last chapter, a number of copper strips buried in the earth, with as large a surface as possible, or even galvanised iron sheets, are employed. In the case of a ship the hull of the ship, or any metal part of the vessel, is used, as this is in direct contact with the water, and forms an ideal earth. If a condenser is placed between the earth and the lower end of the jigger winding, it must be of the variable pattern, so that the capacity can be varied at will. The jiggers used are of various patterns; the primary is generally of thicker wire than the secondary, and has fewer turns, and both are wound on wooden or ebonite frames.

The receiving aerial has a certain amount of capacity, and the larger it is the better. The primary coil of the jigger supplies further inductance, and the two have together a natural time period of electrical oscillation. When the secondary of the jigger and the small condenser are in tune with the antenna circuit, the oscillations set up in the aerial have their energy transferred to the secondary circuit, and there is thus produced in the receiving apparatus a replica on a feeble scale of the actual oscillations set up by the transmitting circuit.

Detection of Signals. These currents are exceedingly small, in a fairly large station often amounting only to small fractions of a micro-ampere ($\frac{1}{1,000,000}$th of an ampere), and to be able to render their detection possible is in reality very wonderful. Minute as the currents are, they appear to be capable of producing heat; in fact, the micro-ammeters used to measure the currents received are often dependent on the heating of a fine wire. One effect of these minute oscillatory currents is to render a bad electrical contact good, and on this property is based the *coherer*, the first detector used for commercial work, but now completely superseded by more delicate and reliable apparatus. In Fig. **18** is seen a small glass tube, having had

the air exhausted so as to produce a vacuum. The terminals, T T, are each connected with a silver plug, S. These plugs are placed near together, and between them are a few nickel and silver filings. The filings cause the contact between the silver plugs to be very bad, yet when an electrical oscillation passes through them the contact is improved to such an extent that a current of electricity can pass through the coherer. In early wireless work this weak current was passed through a relay [see page 4467], and the relay, when actuated, worked a Morse inker, so that the dots and dashes of the Morse code were actually printed on a strip of paper as recorded.

The objection to the coherer is that after each oscillation has passed through it it has to be "decohered" by means of a tap or knock, in order to shake up the filings and render them again non-conductive. This entails special apparatus which is not always easy to adjust. Moreover, the coherer is particularly easily upset, or actuated, by atmospheric discharges of electricity, which produce the same effect upon it as wireless oscillations.

The Magnetic Detector. A great advance was made when Mr. Marconi introduced the *magnetic detector* [26], which has as its outstanding feature remarkable reliability. This detector is sensitive to wireless oscillations, and produces in a suitable telephone receiver a buzz of long or short duration in accordance with the length of the signals transmitted. It consists of an endless "string," made of fine iron wires, which passes round two moving wheels or pulleys actuated by clockwork. In its motion the string goes close to two magnets, with their north poles together, as shown in **19**. The particles of iron in the soft iron wire string become themselves small magnets under the influence of the lines of force of the magnets, and as the band is moving the string drags the lines of the force along in the direction of its motion.

The oscillating currents from the aerial and earth are passed through the coil, A, and they cause this lag in the magnetism of the iron band suddenly to disappear. A second coil, consisting of a much greater number of turns of fine wire, B, is wound over the coil, A, and connected to a telephone receiver, and the sudden change in the magnetisation of the iron band or string induces a current in the secondary, whose terminals, T T, are connected with the telephone receiver. A vibration of the diaphragm in the receiver is thereby caused which produces an audible sound.

The sounds in the telephone receiver last just as long as the sparks in the spark gap of the transmitting apparatus, and hence the signals transmitted are "heard" at the receiving station.

Details of Receiving Stations. A feature of all receiving stations is that the circuit does not only respond to oscillations of its own frequency, but to oscillations whose frequency is a harmonic of those transmitted; hence the detector will respond to oscillations of a frequency of one-third, one-fifth, and so on, of that of the circuit in which it is placed. Where the receiving circuit has the natural or fundamental frequency of the transmitting circuit, the signals are always the strongest; but the fact that harmonics will produce the desired effect renders the tuning very much easier. With damped oscillations, more especially, waves of slightly different wave-length to that for which the receiving circuit is tuned will produce audible signals in the receiver, but they are always weaker than those produced by the waves in proper tune. Modern apparatus usually provides a loosely coupled oscillation transformer, so that, when the tuning has been obtained, the coupling can be loosened until, although the signals are weakened, tuning is very sharp.

When listening for very long waves, such as those of the long-distance transmitting stations, a great deal of inductance has usually to be introduced into the aerial circuit. Very long aerials are employed for the long wave-lengths then employed; and as the average amateur station is usually provided with only a comparatively short aerial, many hundreds of turns of inductance may have to be employed. These long-inductance coils are easily made by winding enamelled wire, of No. 20 or 22 gauge, over an ebonite cylinder of about 3 in. diameter, and having preferably a sliding contact for tuning. The primary coil of the oscillation transformer or jigger is sometimes divided into a number of sections, so that, when tuning, the requisite number of turns of wire can be brought into play by means of a movable contact, C [20]. The looseness of coupling can then be arranged by sliding the secondary coil, S, wound on a cylinder which is movable in or out of the primary, P, nearer to or farther away from the primary. Very effective transformers of this type can now be obtained for amateur stations at very low prices, and are highly effective.

The Crystal Detector. The detector which is perhaps nowadays more used than any other is the *crystal detector*. A piece of crystalline carborundum is sometimes employed, placed between two brass spring clips, but a piece of crystalline silicon, with a gold-pointed wire pressing lightly against it, is the one most used by amateurs. A simple form of silicon detector is shown in **23**. The piece of silicon is fitted into a metal cup, S, and the gold-pointed wire, W, is made to press lightly against it by means of a tension screw, T. Means are usually provided for shifting the position of the cup, or of the wire, as it is always possible to find one particular part of the silicon which is more sensitive than any other. The effect of the wireless oscillations, when passing through the detector, is to cause heating, a thermal change which has a marked effect on the conductivity, the result being a variation in the telephone receiver, which is heard as a dull buzz.

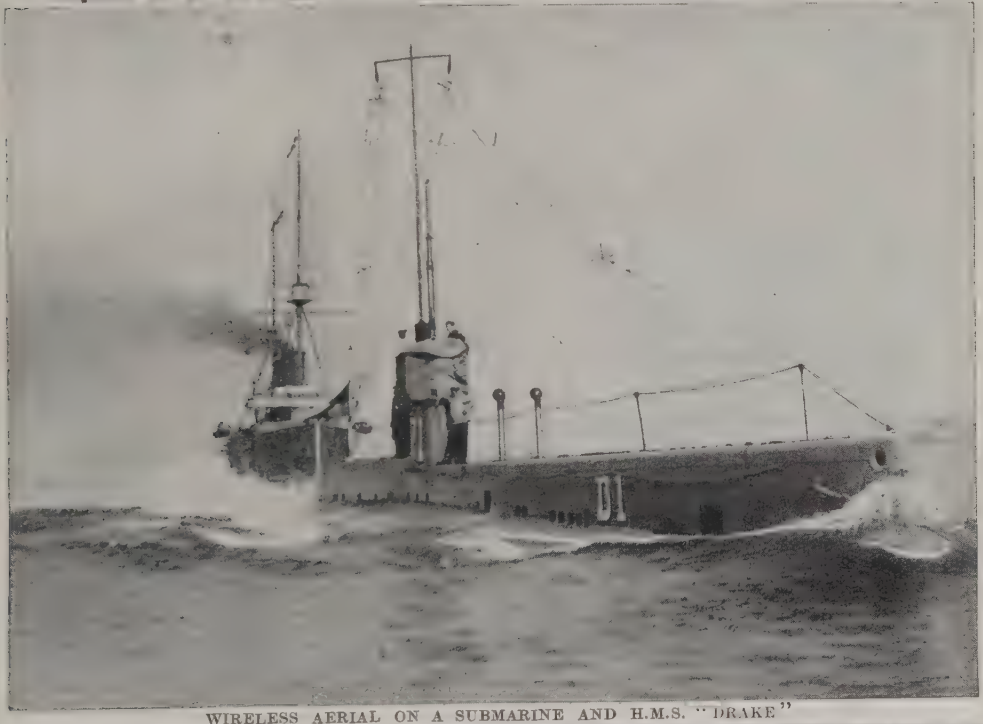
There are various other forms of crystal detector which deserve mention, notably those in which two crystals are made to press lightly against each other. Copper pyrites, zincite, and a number of other crystals are employed, but the effect is the same in each case—namely, a heating of the contact and a resultant noise in the telephone due to the difference of potential caused.

Electrolytic Detector. A detector much in use in commercial stations is the *electrolytic detector*. This depends on the power of the electromagnetic oscillations to affect the passage of currents through electrolytes. De Forest, Fessenden, and Schloemilch are among those who have produced effective detectors of this type. A simple form is seen in **24**. A very fine platinum wire, about $\frac{1}{2500}$th inch in diameter, W, is fitted to the end of an adjustable screw A, which forms the anode (or positive pole), a small lead plate, C, forming the cathode or negative pole; the vessel is filled with dilute acid, and the fine wire, W, just dips into the liquid. The electrolytic cell is placed in series with a voltaic cell shunted by a small potentio-

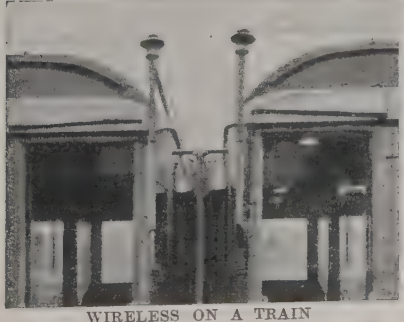
THE USE OF WIRELESS IN PEACE AND WAR

WIRELESS ON AN AMERICAN LIGHTSHIP

THE TRANSATLANTIC STATION AT CAPE BRETON



WIRELESS AERIAL ON A SUBMARINE AND H.M.S. "DRAKE"



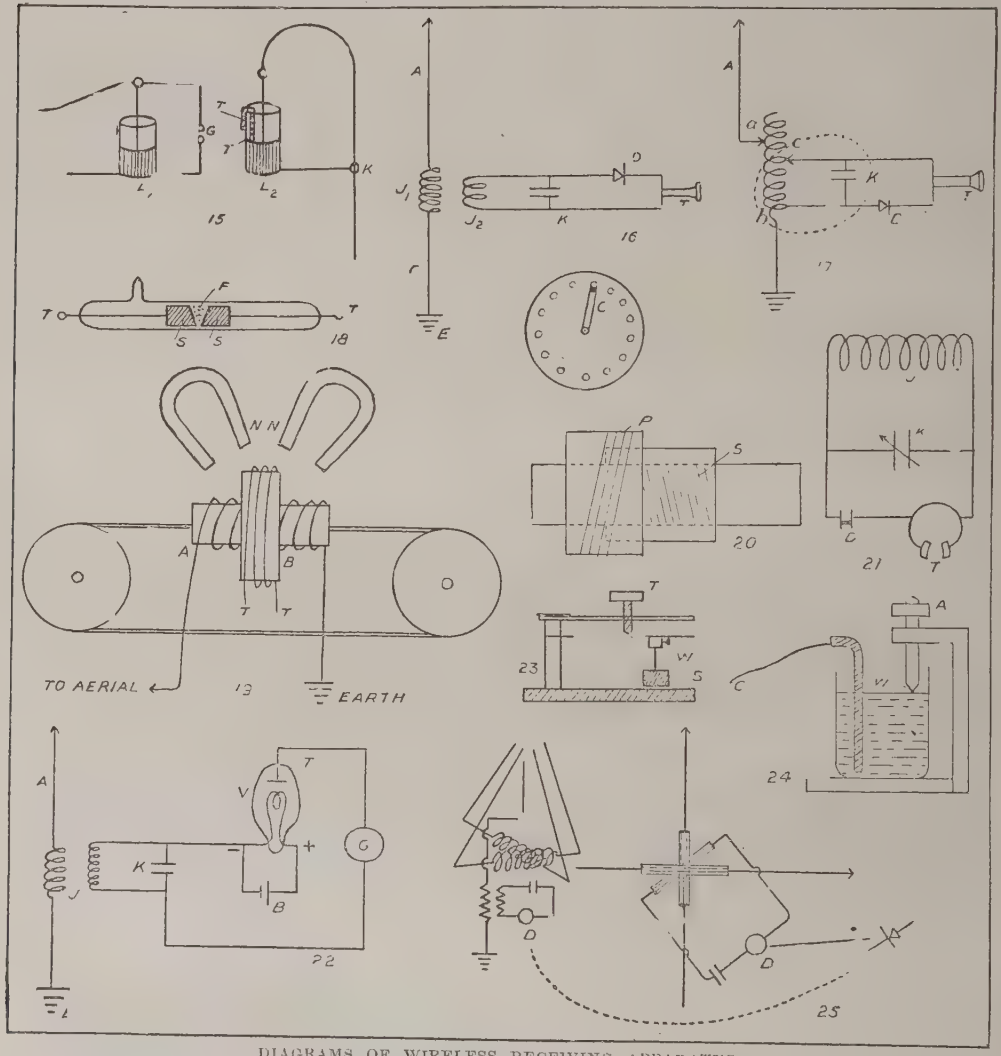
WIRELESS ON A TRAIN

A PORTABLE FIELD STATION FOR CAVALRY

The photographs illustrating this article are by courtesy of "The Wireless World," "The Lighthouse Mission," and Mr. Cribb.

meter, and a telephone is placed also in the circuit. The effect of the voltaic cell is to polarise the electrodes of the electrolytic cells, so that practically no current can flow through the telephone. The effect of the wireless oscillations is to depolarise the electrodes, with the result that current flows through the telephone and a noise is heard in it.

Fleming Valve Detector. The Fleming *valve detector* deserves particular notice, because it is rendered incandescent by means of a local battery, B, when the ionisation produced enables feeble currents to pass from the filament to an electrode, T, and the effect produced is that of *rectification*. Current can pass through the valve in one direction only, hence the small oscillatory currents from the aerial pass through the galvanometer in one direction, and can therefore be measured. A modification of the arrangement is employed when using a telephone receiver, and



DIAGRAMS OF WIRELESS RECEIVING APPARATUS

15. Diagram of resonance of circuits **16.** Simple receiving apparatus **17.** The coil transformer with sliding contacts **18.** Coherer **19.** Magnetic detector **20.** Induction coil for loose coupling **21.** Wave-meter **22.** Fleming valve detector **23.** Crystal detector **24.** Electrolytic detector **25.** Marconi-Bellini-Tosi wireless compass

is in use in many long-distance stations, and is of great value commercially.

One of the valves is shown in use in Fig. **22**. It is an exhausted bulb with a metal filament similar to that of an electric incandescent lamp, and the oscillatory currents from the jigger, J, are passed (with a condenser, K, shunted across the secondary) through the bulb or valve, V, into a very delicate galvanometer, G. The valve filament

this is in use in Marconi receiving stations on a very large scale.

When the received wireless oscillations are rectified in this way, it is possible to measure the infinitesimal amount of current obtained at a receiving station by means of a suitable galvanometer; the movements of the latter can be recorded photographically, and in this way automatic reception is brought about.

THE MASTER-MIND OF WIRELESS TELEGRAPHY

MARCONI, WHOSE WIRELESS SYSTEM SAFEGUARDS THE OCEAN TRAVELLER

Einthoven Galvanometer. The Einthoven galvanometer comprises a powerful electromagnet whose pole-pieces are tunnelled, and fitted with lenses. A beam of light is directed through the pole-pieces and focussed by the lenses upon a moving band of sensitive photographic film. A silvered quartz fibre, about $\frac{1}{1200}$th inch thick, is suspended between the poles of the magnet, and this acts as a minute shutter, which just shuts off the beam of light and prevents it from exposing the sensitive film. The received wireless currents, after rectification through a Fleming valve, are passed through the quartz fibre, and thereby produce a feeble magnetic field around it, whereby it is repelled, or forced to one side, by the repulsion of the field magnets. The beam of light is then able to reach the sensitive film and produce a developable impression upon it. Dots and dashes are represented as short and long deviations respectively of a narrow band on the negative when developed, and a permanent record of the wireless message is thus obtained. Automatic reception of this type has been carried out by Mr. Marconi across the Atlantic, and a somewhat similar type of receiver has been used by Poulsen, for which it is claimed that some 200 words per minute can be received.

The usual method of measuring the received current is by means of a *micro-ammeter*, an instrument which will record tenths, or even hundredths, of the one-millionth part of an ampere (1 unit of current). This is a hot-wire instrument, the heat generated by the passage of the oscillations producing sufficient distortion to cause deflection of a very delicately balanced needle working across a divided scale.

The Brown Relay. Another recent introduction of great commercial value is the Brown relay, by means of which the first or original minute current can be amplified to such an extent that a recording apparatus such as a Morse inker can be operated and the message recorded mechanically. The function of a relay has been described in TELEGRAPHY [see page 4467]. A relay used for wireless work performs the same functions, but essentially is much more delicate. By the use of a Brown relay for ordinary reception, it is possible so greatly to magnify the sounds in the telephone receiver that the receiver can be placed on a table or hung on a wall, and the signals will be audible anywhere in the room. If, instead of passing the amplified signals into a telephone receiver, they be passed into an ordinary automatic telegraph instrument, the dots and dashes of the Morse code will be recorded in ink on a moving paper ribbon. This method of automatic reception is much more useful than the photographic method above described, as the messages can be read the moment received, and no development of a photographic film is necessary. By using a series of relays, each amplified signal being transferred to the next relay, Galletti has recorded messages from Clifden at a station in France, over 1000 miles away, with precision.

The Orling Relay. Another relay which has been employed for long-distance reception for automatic working is that invented by Orling. In his instrument a projecting wire is fastened to the moving coil of a sensitive galvanometer, and this fine wire projects into a thin jet of acidulated water. When wireless oscillations pass through the moving coil (suspended between the poles of a powerful magnet), the coil twists slightly, and the fine wire deflects the water jet on to a contact, so that a local current is established, the jet itself forming part of the circuit.

Measurement of Waves. The measurement of the length of the waves used in wireless telegraphy is often of great importance. The *wave-meter* most ordinarily used is that made by the Marconi Company, and consists of a variable condenser placed in series with an inductance coil, this being usually made in two sections to give a wider range of use. The arrangement is shown in Fig. 21. J represents the inductance coil, which is wound inside the lid of the box containing the other apparatus; K is a variable condenser, D a carborundum crystal detector, and T the double headpiece telephones. When making a measurement, the telephones are placed to the ears, and the box is held a little distance away from the wireless circuit; the condenser is then adjusted until the signals are heard with the maximum loudness. By referring the figure on the scale of the condenser to a table already worked out, the wave-length is immediately found.

The distance over which messages can be transmitted depends very largely upon the wave-length employed, hence in long-distance transmissions a wave of seven or eight thousand metres is often used. As the natural wave emitted by the aerial is between four and five times the length of the aerial, it is desirable to have the aerial as nearly as possible in accordance with one-fifth of the wave used. This is the reason why in powerful stations aerials half a mile or more in length are used. As regards the reception of messages, a very long aerial is equally important, even though by reason of its length it may be necessary to use a condenser in series with it. Mr. Marconi recently, by means of an aerial suspended from a kite on board ship, received messages at a distance of over 6000 miles, and it is thought that this distance could have been increased had not a rise in wind necessitated pulling in the aerial.

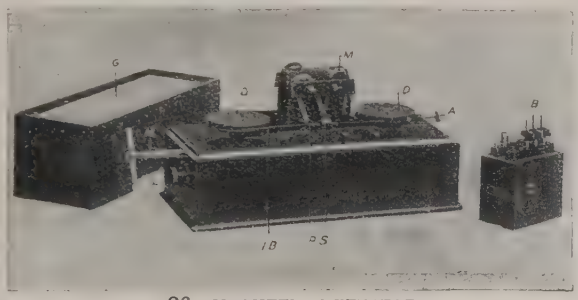
Portable Sets. Military work requires a complete wireless installation of as portable a character as possible, which must, of course, be absolutely self-contained. The Marconi military set can be carried on five or six pack-horses, and consists of portable masts in sections which can be quickly put together, a small transmitter supplied with current from a dynamo driven by a small petrol engine, and a convenient receiving station mounted in a cabinet, in which the operator is protected from wind and rain. The masts are built up from their sections, and the aerial wire unrolled from reels, and suspended between the two masts. A roll of wire netting is spread over the ground to act as the earth, and the dynamo and generator are mounted one each side of one of the horse-saddles placed on the ground, with a direct-drive axle connecting them. A special feature of the system is that a key is provided with which the wave-length can be quickly changed, there being three available waves to work on. This makes it possible to avoid interference or interception of the messages to a great extent. The Fleming valve is used as the detector.

Portable receiving sets have also been made, sufficiently small in size to admit of the whole apparatus being fitted inside a knapsack; but unless an aerial fifty or more feet in length can be obtained at a reasonable height, and a good earth, there is little possibility of picking up anything but very strong signals, or signals being transmitted from a station not very far away.

Wireless in Airships and Aeroplanes. In the case of airships and aeroplanes the matter is different. As no earth connection is possible, one of two methods can be employed: either *balanced aerials*—that is, two equal aerial wires with a spark-gap between—like the original Hertz oscillator, or one aerial wire and a metal capacity. For the latter purpose such things have been tried as coating the gas envelope of an airship with aluminium leaf. It is quite customary, also, to have the aerial wires attached to insulators above an aeroplane, disposed like a fan or in some similar convenient fashion. In the early days of flight, when the author carried out the first experiments in this country on Salisbury Plain, two aerial wires were used on each side of the aeroplane, extending from the pilot's seat to the extreme edge of the planes and then back to the tail. This was a Hertz oscillator type of arrangement, and worked fairly well within a range of a mile or two.

It is very difficult to receive messages in aeroplanes, as the great noise of the engine and the vibration render hearing most uncertain; and as only very faint signals can be heard, the sounds in the telephone receiver are extremely low. Another difficulty in tuning is that the capacity of the aerial wires varies with their height from the ground, so that the conditions are in general highly unsatisfactory.

Wireless on Submarines. A considerable number of submarines are now fitted with wireless telegraph apparatus, but they are obliged to rise to the surface in order to hoist up the aerial above the water. The mast and antenna are thus what might be termed "collapsible." The range is, of course, limited, owing to the fact that a high mast is not possible, but a low or short aerial can always, to some extent, be compensated for by the use of a powerful transmitting apparatus. Continuous oscillations are of value here, as not only are they more efficient, carrying a greater distance for the same amount of power, compared with damped systems, but they have as long a range in daytime as at night. This is a peculiar feature of undamped waves which gives them a great value over damped waves.



26. MAGNETIC DETECTOR

A. Adjusting screw for varying tension of iron band *B*. Telephone condenser plugs *C*. Telephone condenser *D*. Ebonite discs *G*. Glass-fronted cover *H*. Winding handle for clockwork *IB*. Iron band *L*. Clockwork control *M*. Magnet *P*. Primary coil *S*. Secondary coil.

By courtesy of the Wireless Press, Ltd.

Transmission without Aerials. There is another system of wireless transmission in which no aerial is employed at all, the waves travelling through earth or water; and although up to the present the distance covered has not exceeded six or seven miles, there is little doubt that it could now be greatly increased. Telephony is as easy by this method as telegraphy. A microphone is placed in series with a battery and small, low-resistance induction coil, and the ends of the latter are also connected with two wires stretching about fifty or sixty feet in opposite directions, and terminating in metal plates, either suspended in water or buried in the earth. The receiving station comprises a telephone receiver similarly connected with two wires terminating in metal plates. On speaking into the microphone, conduction waves are generated which travel outwards from the metal plates, and are picked up by the receiving plates and reconverted into speech in the telephone.

Sharman and Thorne Baker have also transmitted wireless signals through the earth over a considerable distance by merely having the wires ordinarily leading to the aerial and earth of an ordinary transmitting set attached instead to earth plates, similar earth plates at the receiving station leading to the receiving circuit. Quite sharp tuning is possible with this method of transmission, showing that wireless oscillations will travel through the earth in the same manner as they do through the ether under ordinary conditions.

The Wireless Compass. A great deal of work has been done recently in the determination of the direction in which wireless oscillations are travelling, the most practical apparatus being that invented by Bellini and Tosi, and since very much improved by Marconi. By means of the *wireless compass*—the name which has been applied to the apparatus—a ship can determine the locality from which signals are emanating, and by locating two—or, better, three—known stations, it can, in a fog, determine its own position with a considerable degree of accuracy. Many large liners are now fitted up with a wireless compass, and at certain dangerous points along the French coast special signals are sent out in foggy weather for their guidance.

For the purpose of location, a compound antenna is used; two nearly closed aerials (triangular shaped) are fitted up, usually disposed nearly at right angles, and one vertical single aerial, as shown in **25**. The vertical aerial and earth are connected with the ends of the primary or secondary of the oscillation transformer. The inductive coils of each triangular aerial are placed at right angles, and fixed as shown in the diagram, and the inductive coil of the plain aerial is placed inside them, and it can be rotated. To determine the direction of the signals, the movable coil is swivelled round until the sounds heard in the telephone are of maximum intensity. Two readings are sometimes taken of the positions of the movable coil when the signals in the telephone receiver just fall below audibility. There will, of course, be two such positions, one each side of the position of *maximum* intensity. These angles are measured by an indicator on a divided circle, and the direction of the signals then found by dividing in half the angle between the two measured positions. This gives accurately the position of *maximum* intensity.

Bellini and Tosi have constructed somewhat similar apparatus for directing transmission, but the real utility of their compound aerial and goniometer, or compass, lies in the ability of ships to determine their position by locating known transmitting stations. T. THORNE BAKER

Pronunciation. Nuances. Expression and Tone Colour. The Art of Correct Phrasing. Elocution and Declamation. How to Study a Song.

ARTICULATION AND PHRASING

Articulation. The great mistake so many singers make is that they give their undivided attention to the fulness and beauty of their voices, paying no heed to the diction; the words count for nothing, and are never thought of at all. It is as essential in singing as it is in speaking that the words should be clearly heard and the correct accent used—in other words, that the articulation and pronunciation should be irreproachable.

Articulation must not be confused with pronunciation, for there is a great difference between them. Words are made up of syllables. Each syllable contains one vowel and one or more consonants. When each vowel and consonant is clearly and correctly uttered, the *articulation* is perfect. The reason why English people articulate so indistinctly is that they hurry over their words. More *deliberate* articulation is needed. The famous Mrs. Siddons used to say to her pupils, "Take time!"

It will be found that the consonants offer greater difficulties than the vowels, so the first exercises will be on the consonantal powers.

It must be borne in mind that the consonants are not all formed alike. Roughly speaking, they are divisible into five groups:

1. LABIAL, formed by the approximation, or the complete contact, of the lower and upper lips—pen, bat, man, wench.

2. LABIO-DENTAL, formed by the contact of the lower lip with the upper teeth—fine, verse.

3. LINGUA-PALATAL, formed by the tip of the tongue coming into contact with the hard palate immediately behind the two upper front teeth—ten, did, line, night, sell.

4. LINGUA-GUTTURAL, formed by the back of the tongue coming in contact with the hard palate—kind, gag.

5. ORAL, formed by a full flow of breath through the mouth—hall, yolk.

The student must first persevere with the actual powers themselves, and not add the vowels until the consonants have been *thoroughly* mastered, thus:

B	as in bad	N	as in name
C	,, cakes	P	,, pill
D	,, dane	Q	,, quilt
F	,, fight	R	(trilled) as in rat
G	,, gauge	R	(smooth) as in war
H	,, hat	S	as in sill
J	,, jet	T	,, tone
K	,, kick	V	,, vain
L	,, lark	W	,, well
M	,, mart	X=KS	as in mix
		Wh	as in white

Each of the powers given in the above list, beginning with B, must be practised at first *very slowly*, thus: B′B′B′B, breathing after each B. Then in four groups of two, breathing after each group; four groups of four, breathing after each group; four groups of eight, breathing after each group; then in groups of twelve, sixteen, twenty, and so on. The greater the speed, the lighter and crisper must be the articulation. The sound actually uttered is not Bee, but B as heard in the word "bad" minus the "ad" sound.

After having practised the above exercise the student should make out lists of words for each consonant, thus: Ball, bat, bell, bed, bile, bid, boy, boil, book, booth, etc. Then sentences something like these: "Black Benny Bumpkins bought beautiful blackberries, but Bertha Brown bartered Benny's best boat for bananas."

This must be practised carefully in two breaths—that is, breathing after blackberries; then the whole exercise in one breath: afterwards tried twice, three times, and four times, if possible, in one breath, throughout paying the greatest attention to the "B" power.

Having learnt something of the consonantal powers, the student must turn his attention to the vowel sounds. Whilst only five signs are used—A, E, I, O, U—they represent a great many more vowel sounds.

Five sounds for A, as in ape, ah, all, at, air.
Three sounds for E ,, eel, ell, earth.
Two sounds for I ,, ice, ill.
Two sounds for O ,, old, odd.
Three sounds for U ,, up, (n)ude, (f)ull.

O is also represented in the diphthongs, as in boy and owl.

Although the vowel sound emanates from the larynx, the real formation is decided by the different shapes assumed by the inside of the mouth and the pharynx.

The student must make for himself lists of words on each of the vowel sounds given above, thus: A as heard in ape, ale, fate, pate, grate, and practise them many times, listening carefully to each sound produced, and continue until he has thoroughly mastered them.

When he has overcome the difficulties in the preceding exercises, he should take sentences such as this from Ruskin:

"Blue, baseless and beautiful
Did the boundless mountains bear
Their folded shadows into the golden air."

Recite them very slowly, and pronounce every vowel sound fully, correctly, and distinctly.

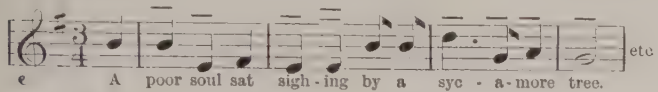
Pronunciation. Good pronunciation is really "proprietry of delivery." It is not so easily taught as is articulation; so much depends upon the student's own intelligence and his capabilities for hearing and discriminating between words correctly and incorrectly pronounced.

To a very large extent, correct pronunciation depends upon their proper use; but besides practising the vowel sounds, it is necessary to hear, listen to, and copy the best orators and actors of the day if good pronunciation is to be obtained.

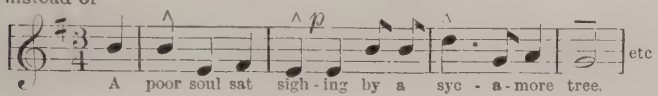
Apart from the different brogues of Scotland, Ireland, and Wales, the English counties have peculiarities of pronunciation that ought to be eradicated, such as: "t' cat" for "the cat" (North Lancashire); "th' cat" for "the cat" (South Lancashire); "Charing-Crawss" for "Charing Cross" (Cockney); "Eow" for "Oh" (Cockney); and many more that can only be corrected by listening to a cultured speaker. It is not intended that the student should regard pure dialects as

vulgarisms; it is the mixture of "polite speech" and dialect that is so ugly. In a number of real dialect words many of the roots of the English language are traceable, for they are chiefly of Celtic, Teutonic, Scandinavian, and Anglo-Saxon origin.

It is generally imagined that the English language is bad for singing. The sooner this absurd idea is abolished the better. The real reason why a voice does not sound so full and resonant when singing English words as it does when singing Italian is that the singer neglects to give the full value to the vowel sounds, and does not articulate his consonants sufficiently, besides invariably "clipping" them. Another common mistake made by singers is that they are not careful to give each syllable its proper accent, for example:



instead of



As first marked, the words would read as follows, and make no sense:

"A *poor soul* sat *sighing* by a *syc-a-more tree.*" We do not pronounce the letters s y c a m o r e as *syc-a-more,* but syc-amore, so why sing the word with three accents?

The consonants must be more marked in singing than in speaking, because the vowels are more prolonged and have often to be made broader.

Great care must be taken that the end of a word is not carried on to the beginning of the next—that is to say, it must be finished on the note intended by the composer; the consonants must be articulated distinctly, especially the d's and t's; and the r's trilled where necessary, but under no consideration must false accents be introduced in the endeavour to begin or finish the words.

Nuances. "Messa di voce" has been defined as "the swelling and diminishing of the sound of the voice upon a holding note." To obtain this a note must be attacked *very* quietly, gradually increasing in force until the loudest tone is obtained, then must be diminished carefully and gradually until the original power of tone is reached.

These swelled sounds are shown thus , and this sign usually applies to *one* note only, although it may happen that a whole phrase is to be included. But in either case it must be executed in *one* breath. At first the student must practise half the exercise—that is, begin very softly, making a gradual crescendo from the softest to the loudest tone. This should be practised twenty times, then the process should be reversed, begun very loudly, gradually diminished to a *pp.* This, too, should be practised many times. Finally the whole exercise should be practised.

Rules for Singing "Messa di Voce." The following rules must be observed:

(1) Breath must be inhaled slowly, calmly, quietly, and deeply before each exercise.

(2) The vowel sound must not alter as the note becomes louder or softer.

(3) Once the note is attacked the mouth must remain unaltered.

(4) The quality of the note must be unchanged throughout.

(5) The note must *not* be held until the last particle of breath has been exhaled; a little must remain in the lungs after the completion of the note or phrase.

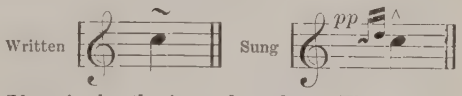
The "messa di voce" may be practised on all the notes suitable for the respective voices, given in Ex. 1 [pages 5765–6], the vowels A (ah) and E (ee) being used.

The object of "messa di voce" is to give colour to the singing. It must not be attempted until the student has acquired a correct management of the breath.

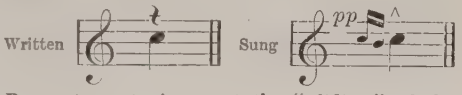
The principal ornaments used in singing are the appoggiatura, acciaccatura, mordente, grupetto or turn, shake or trillo, portamento, legato, staccato, and picchettato.

[The ornaments appoggiatura, acciaccatura, grupetto or turn, shake or trillo, are explained fully in the chapter on "The Whole Language of Music," on page 236; their meaning should be thoroughly understood by the singer.

The mordente consists of the written note, the note above—either tone or somitone—and the written note.



There is also the *inverted mordente.* This consists of the written note, the note below and the written note.



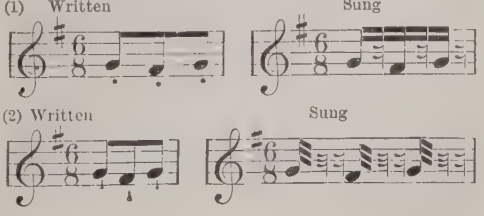
By portamento is meant the "sliding" of the voice from one note to another of different pitch. When used with discretion it is very effective, but a common mistake made by many singers is that they use it continually without discretion. As to how it must be sung—slowly, or quickly, loudly or softly—the student must be guided entirely by the context. The following sign ⌒ or ⌒ is used.

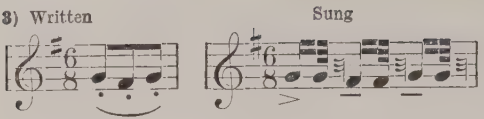
A note must never be "slurred" to and then from consecutively.

The sign called a slur, used for the legato, is written ⌒. The notes over which the slur is placed must be sung very smoothly, but there must be no "sliding" of the voice from one note to the next, and the notes intervening between the written notes must *not* be heard as in portamento.

Great care and perseverance must be exercised before the legato can be acquired; but once the student has mastered its difficulties, he is amply repaid, for, as Signor Randegger says, "Efficiency in *legato singing* is the most prominent and valuable attribute of a good singer."

Speaking generally, it may be said there are three kinds of staccato.



3) Written Sung

No. 1 is usually called staccato, and No. 2 picchettato. The notes marked picchettato are half as short again as those marked staccato.

The strictest attention must be given to the rests between the notes; neither the voice nor the breath must be heard.

Breath must not be inhaled between the notes, but that which was inhaled at the beginning must be regulated so that it is sufficient for the whole phrase. Each note must be firmly and sharply attacked.

In singing No. 3 the notes should be firmly attacked, but not so marked or detached as in Nos. 1 and 2. The student is advised to write exercises for himself on the different ornaments and embellishments, and then practise them carefully and diligently in the keys best suited to his voice.

Word Picturing. Upon "word picturing," facial expression, tone colour, emphasis, expression, and phrasing, all to a large extent depend. Each of the above will be treated separately; but it is essential that the student should first really understand what is meant by "word picturing."

Before a student can do justice to a song he wants to sing he must take the words apart from the music, read them through carefully and thoughtfully, then re-read them. They may be merely descriptive, or they may be of an emotional nature combined with description. No matter of what nature they may be, the student must draw upon his imagination and make *mental pictures* of the scenes and emotions to be portrayed, as an artist has to do before he can place on canvas illustrations of a poem.

To a painter this word picturing is, perhaps, more natural than to a singer; the former is trained from the first to make a mental picture of all he reads. Here is this difference between the painter and the singer; as the latter will probably have to describe the whole of the poem, he must, perforce, *mentally see* the *whole* of it, whereas the painter is limited to a few lines, for he cannot paint a picture illustrating the whole of the poem.

The student will find it very helpful—until he is able to draw upon his imagination more, and mentally make pictures for himself—to recall past experiences in his life, and work on them. For example, if he is singing of a lovely garden, or a quiet graveyard, he must think of some garden he knows that once appealed to him, or a quiet, peaceful graveyard he has seen and noticed; if he is singing of a person, he may think of someone he knows who seems to fit the situation; if his song refers to the passions or emotions, he must think of the time when he hated, was afraid of, loved, or was angry with some person, and he must try and recall some of the feelings he may then have experienced, and work them into the song. The whole of what is represented in the song must be *mentally seen* if he wishes to make the rendering of it clear to his audience.

Facial Expression. For examples of real facial expression one should look at the face of a child. How quickly its little face brightens, and with what smiling eyes it looks at one when anything pleases it! On the other hand, how suddenly its wee face clouds if it is disappointed, and how it pouts when it is cross!

As the child grows up it gradually loses this natural unconsciousness of self, and perhaps unconsciously strives to hide these varying expressions which are the outcome of the thoughts and emotions. English people are much too reserved; they will not speak with their eyes and the expression of their faces—they rely entirely upon the mere words.

For those whose calling does not bring them before the public, this may be passable; but to anyone who wishes to be a singer, reciter, or public speaker, facial expression is as essential as a properly produced voice. The expression of the face must change with the mood.

No hard and fast rule can be laid down for facial expression, as all the expressions natural to one's face are the outcome of one's inmost thoughts.

The student must make a list of the different emotions—love, hatred, rage, and so on, and, standing before a mirror, practise the different facial expressions which represent each. He will see for himself how necessary it is to get a thorough reading of his song, and practise his "word picturing." When these have been mastered, facial expression will come quite naturally to him.

Tone Colour. When the student has thoroughly grasped the meaning of the words of his song, and made himself quite familiar with all the moods contained therein, he will unconsciously have acquired the correct "tone colour" for each musical sentence. He would not use the same "tone colour" for "O rest in the Lord; wait patiently for Him," that he would for "Awake, Saturnia, from thy lethargy!" For the former he would use a warm, comforting, persuasive tone, whilst for the latter he would use a sharp, commanding, peremptory one. Ere the student can hope to attain proper tone colour, he must thoroughly understand the words he is about to sing.

Emphasis. Some singers may argue that "emphasis" does not apply to singing; that it chiefly concerns readers, reciters, and speakers. This is not so; it is as necessary to the singer as to the speaker. Every word in a phrase must be given its due importance, but one of them must be more strongly emphasised than the others, to point to the real meaning of the sentence.

The whole sense of a passage may be altered if emphasis is not put on the right word. The following examples show the correct and incorrect emphasis: "Greater love hath *no* man than THIS, that a man lay down his *life* for his friends." Properly emphasised, the word "*this*" takes the especial prominence, whilst the words "no" and "life" are the next in importance.

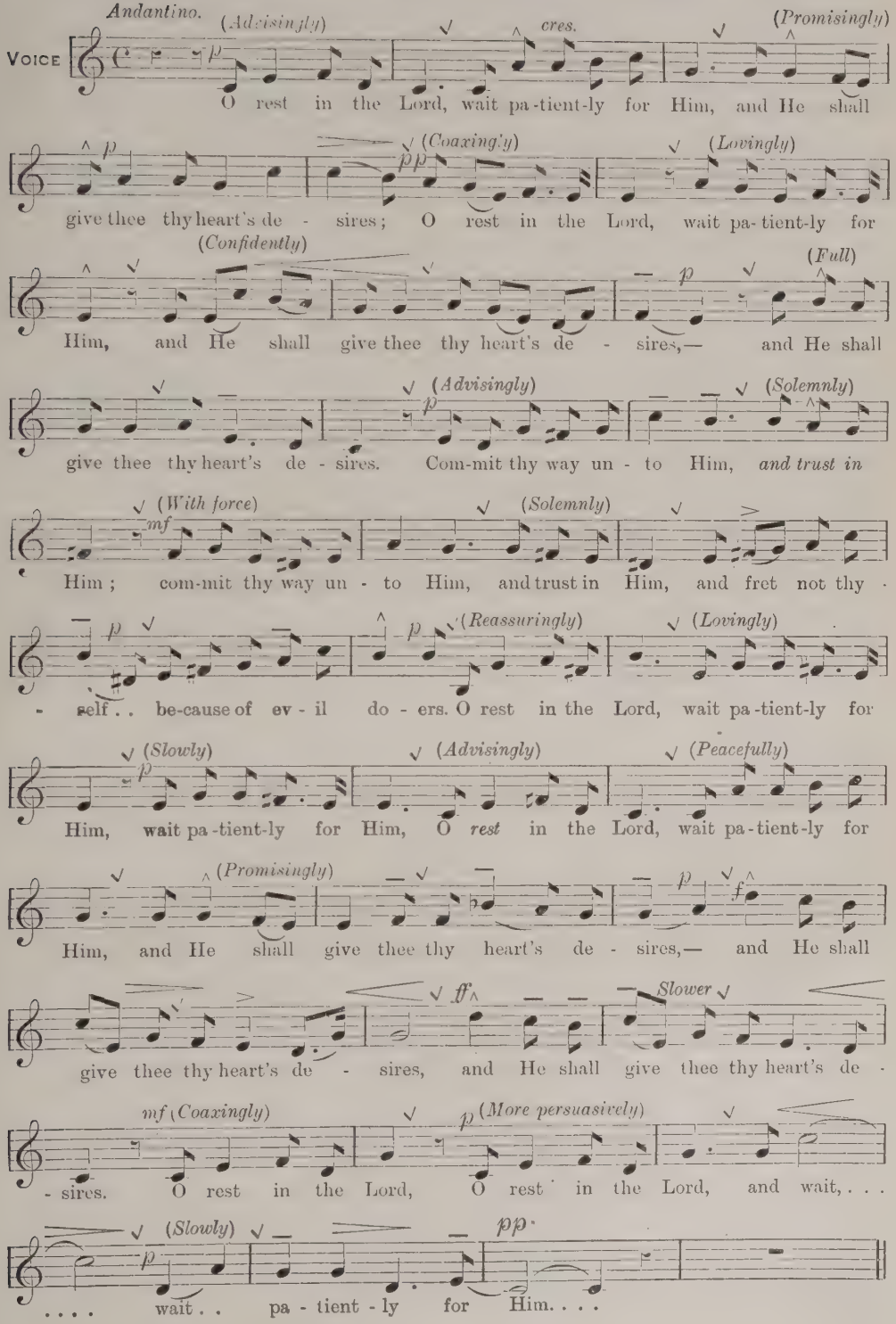
Wrongly emphasised, it would read as follows: "Greater love hath no *man* [as opposed to "woman"] than this, that a man *lay down* [not "take up"] his life for his friends."

The student will see for himself how this sentence can be turned about, and wrongly emphasised and made absolute nonsense of; further, he will see how essential it is that singers, as well as speakers, should emphasise correctly.

Expression. Rousseau says: "Expression is the power whereby the musician conveys to his audience all the ideas and sentiments of the music which he interprets, at the same time making it evident that he feels them himself."

Some natures are less responsive than others, but with patience, perseverance, and a tactful handling, feeling can be brought out of the coldest natures. The terms expression and feeling, as applied to singing, are synonymous, therefore every person is capable of singing with "expression."

Aria—"O REST IN THE LORD."


Andantino.
(Advisingly)
cres.
(Promisingly)
Voice
O rest in the Lord, wait pa-tient-ly for Him, and He shall
(Coaxingly)
(Lovingly)
give thee thy heart's de - sires; O rest in the Lord, wait pa-tient-ly for
(Confidently)
(Full)
Him, and He shall give thee thy heart's de - sires,— and He shall
(Advisingly)
(Solemnly)
give thee thy heart's de - sires. Com-mit thy way un - to Him, and trust in
(With force)
(Solemnly)
Him; com-mit thy way un - to Him, and trust in Him, and fret not thy -
(Reassuringly)
(Lovingly)
- self . . be-cause of ev - il do - ers. O rest in the Lord, wait pa-tient-ly for
(Slowly)
(Advisingly)
(Peacefully)
Him, wait pa-tient-ly for Him, O rest in the Lord, wait pa-tient-ly for
(Promisingly)
Him, and He shall give thee thy heart's de - sires,— and He shall
Slower
give thee thy heart's de - sires, and He shall give thee thy heart's de -
(Coaxingly)
(More persuasively)
- sires. O rest in the Lord, O rest in the Lord, and wait, . . .
(Slowly)
. . . . wait . . pa - tient - ly for Him. . . .

Expression cannot actually be taught, but it can be cultivated, and to such an extent that the performer really feels what he is singing; and, what is still more important, makes his audience feel it, too. There are, of course, some people whose singing is naturally sympathetic and full of feeling, but this need not discourage the less fortunate ones, for everybody who wishes can sing with expression. The easiest and quickest way to cultivate this great gift is to read good literature, especially poetry, thoughtfully and with understanding.

Phrasing. Phrasing may mean merely a correct punctuation of a musical phrase, as: "Woe! Woe unto them who forsake Him!" (Elijah); but when one speaks of a song and piece being correctly "phrased" one generally understands that the best possible effect has been given to each of the musical sentences contained therein. This can only be accomplished after the performer has thoroughly grasped the *meaning* intended by the composer, and fully realised his ideas; he will then portray them in such a way that the audience cannot fail to grasp them too.

Besides this, he must have mastered the art of breathing, have had his voice properly produced, have studied articulation and pronunciation, be able to keep time and sing "in tune," know where to take breath, be able to use the correct "tone colour," be able to sing legato and staccato, and be thoroughly proficient in the singing of all the different ornaments and embellishments. Lamperti, in his famous "Art of Singing," says that "the whole beauty of the art of singing lies in phrasing."

We give on the next page "O rest in the Lord" fully marked, and the student is advised to study it well. For his guidance we also give a list of the signs used:

√ Where breath is to be inhaled.
| Voice to cease, but no re-inhalation.
/ Inflection of the voice to rise.
\ Inflection of the voice to fall.
∧ Strong accent.
– Medium accent.

Elocution and Declamation. It is essential that the student of singing should study elocution and declamation. Unless he does so he will find it almost impossible to deliver his song to its greatest advantage—to give it the poetical sense and the true expression intended by the composer. Many teachers of singing are quite opposed to their pupils' studying elocution and declamation. They imagine it injures the singing voice; but this is an absurd idea. If the student uses his speaking voice properly and in moderation, no possible harm will result. Cavaliere Alberto Randegger, one of the most famous professors of singing, writes: "Elocution and declamation should form an integrant part of the singer's education."

A dictionary would probably describe a song as a short poem, a ballad, a lay or a strain, but none of these synonyms fully define the word. A song is the combination of words with the singing voice. One is indispensable to the other, and they are equally important. When it is remembered that words set to music make the conception absolute, it will be seen how important a part they play.

The First Song. The first song chosen should be very simple, slow, sustained, well within the compass of the voice, the intervals not too difficult, and the accompaniment quite easy, so that if the student is obliged to play his own accompaniment he can do so without paying much attention to it, and so give all his thoughts to his voice and the words. A short song such as "The Sweetest Flower that Blows," by Hawley, or "The Night has a Thousand Eyes," by Frank Lambert, is recommended.

The student must read through the words carefully, and when he has grasped their meaning read them aloud as though they were the outcome of his own thoughts, breathing where the sense dictates.

Before beginning to sing them he is advised to learn them by heart. He should then give his attention to the song, first noticing the key, time, and marks of expression before uttering a sound. Next he should slowly sing through the melody to "La," keeping perfect time; and finally he should take the words and music together.

Recitative may be defined as a musical declamation or a speaking in music. There are two kinds—accompanied and unaccompanied. In singing the former the student must keep strict time. Example: "Awake, Saturnia" (No. 28, Handel's "Semele").

When a recitative is unaccompanied the singer makes the time according to the words of the story and his own reading of the piece. Example: "O, worse than death" (No. 17, Handel's "Theodora").

For both accompanied and unaccompanied recitative singing the meaning of the words must be very carefully studied, so that the sentences may be correctly phrased and the proper emphasis given. At all times must the words be clearly pronounced.

When studying the unaccompanied style, the student is advised to select several recitatives, and take the words quite apart from the music and read them aloud as he would a verse of poetry or a piece of prose. Having satisfied himself that he has obtained the correct meaning and effect, he may then sing them, but the phrases must be the same as when declaimed.

Three Styles of Singing. Generally speaking, there are three styles of singing—plain, florid, and declamatory. For the first the essential and distinct attributes are perfect intonation, correct breath management, and faultless diction. This is the noblest of all styles, and to it belong church music and oratorios. Example: "If with all your hearts" (Mendelssohn's "Elijah").

The florid style is not so frequently heard nowadays as it was some years ago. It is full of ornaments—grace-notes, shakes, turns—arpeggios, scale passages, etc., and the "tempo" is usually quick. For the singing of this the voice must be light and full, and the breath well under control. Example Bishop's "Lo! here the Gentle Lark."

It is to the delivery of the words that the attention is chiefly given in the singing of the declamatory style; vocalisation is practically unnecessary. Example: Schubert's "Aufenthalt."

The Young Singer's Début. It is quite possible that the average student will feel very nervous and awkward when he makes his début as either a professional or amateur singer. This is natural enough, and only time and experience will enable him to obtain perfect self-possession; but he should bear in mind that however nervous or anxious he may feel he must do his utmost to hide it, for nothing is more trying to an audience than a nervous performer. He should come well forward on to the stage, and his face should assume a pleasing expression. The student may at all times be *anxious* when he sings publicly, but it is certain he will not be nervous if he understands and has thoroughly mastered the piece he is about to sing.

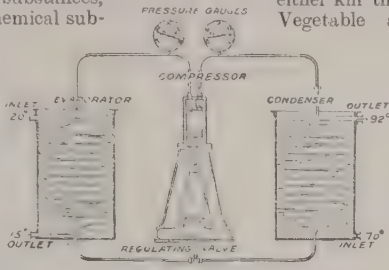
MARY WILSON

Cold Storage. Refrigerating Machines. Milk Pasteurisation and Refrigeration. Tinned Foods. Chemical Preservatives. Fruit Preserving. Jam Making. Condiments.

FOOD PRESERVATION

It is a common matter of everyday experience that most foods, especially those of animal origin, are subject to decomposition if kept beyond a certain period. Before we can properly appreciate the value of the different methods of preserving foods it is absolutely necessary for us to form a clear conception of the causes which bring about decomposition and putrefaction.

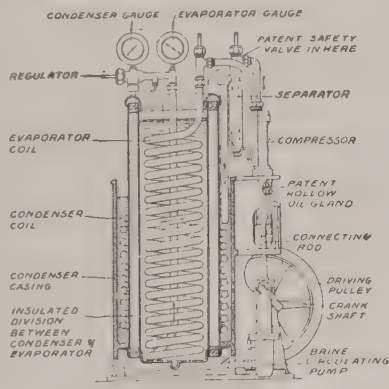
Why Food will not Keep. Foods are mixtures of complex organic substances, and when they go bad these chemical substances undergo chemical changes with the formation of other substances characterised by their unpleasant taste and smell, or by poisonous properties. These chemical changes are brought about by minute organisms (micro-organisms), which are invisible to the naked eye. [See Bacteriology]. All decomposing substances, when examined under the microscope, are seen to be swarming with innumerable organisms of varying shape and form. They are so universal that it is no easy matter to prepare liquids free from them and keep them in this state. Water taken from any pond, well or stream, even fresh rain water, teems with life when examined in this way. Like all living things, these micro-organisms bring about the chemical transformation of matter by "feeding on," or absorbing, substances in one form and excreting them in another, or else producing ferments which bring about these changes. It often happens that substances produced by one organism become the food of another, so that a whole series of chemical changes are brought about. This happens when any animal foodstuff undergoes putrefaction. The danger of consuming such food lies in the small quantities of poisonous products (ptomaines) they may contain. In the early stages of decomposition food is often covered with furry growths, commonly known as moulds. These are well characterised forms of plant life. They are of considerable importance as they prepare the way for the development of other more minute organisms and bacteria. If only we could exclude these organisms, it might be possible to preserve even the most perishable of foods indefinitely.



1. REFRIGERATING MACHINE
[Diagrammatic view]

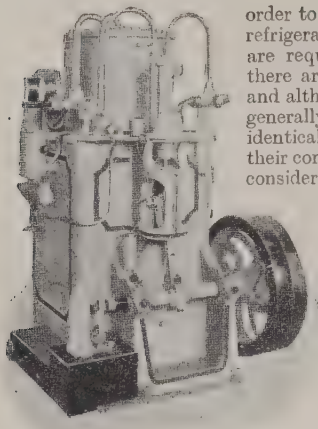
How Bacteria are Kept in Check. Having shown that food will not keep because of the action of micro-organisms, it will now be our business to inquire into the conditions under which they live, in order that we may learn how to control them. The spores, or seeds, are extremely minute, are always found floating in the air, and are continually settling like dust on every object. Wherever they find favourable conditions and suitable surroundings they quickly obtain a foothold, and breed and multiply. These conditions may be classed under four heads: (1) Supply of suitable food; (2) presence of moisture; (3) suitable conditions of temperature; (4) absence of substances which either kill them or prevent them developing. Vegetable and animal matter, including foods for human consumption, all provide suitable food for micro-organisms, but it is essential for their development that moisture should be present, hence the primitive method of preserving food by drying, and therefore excluding moisture. Thoroughly dried foodstuffs will keep an immense time. The organisms may be there, but have not a chance of developing.

Cold Storage. Food may be preserved by taking advantage of the fact that bacteria will only develop within a certain range of temperature. Thus below about 50° F. their activity is almost entirely arrested; above 170° F. bacteria are destroyed. We shall confine our attention, to start with, to those methods of preservation dependent upon low temperatures, and generally known as refrigeration, or cold storage. The food, whether meat, fish, vegetables, or fruit, is kept at a low temperature until required for consumption. This is perhaps the best method of preserving food as it adds nothing to and takes nothing from the article, so that no change is brought about, and the food remains as nutritious and digestible as before treatment. The advantages of cold storage will become apparent when we see some of the disadvantages attached to the other methods of preserving food. By the aid of cold storage hundreds of thousands of tons of different foodstuffs are imported annually into this country without the use of any chemical preservative. When the ship arrives here the foodstuffs are taken out of the refrigerating chambers, and placed in cold stores until required. We shall now describe the machinery and plant used in this connection.



2. SECTION OF A LAND TYPE OF REFRIGERATING MACHINE

Refrigerating Machines. The rooms in which foodstuffs are stored are generally kept cool by a system of overhead pipes through which cooled brine circulates. Brine is chosen, as it can be reduced to a low temperature without freezing. In

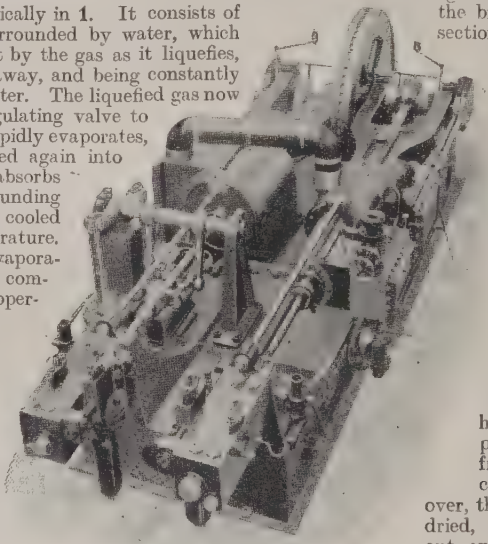


3. LAND TYPE OF CARBONIC ANHYDRIDE REFRIGERATING MACHINE

order to cool this brine refrigerating machines are required, of which there are several types, and although those now generally employed are identical in principle, their construction varies considerably. The principle involved is as follows:

By means of a compressor, certain easily liquefied gases, such as carbon dioxide, ammonia, or sulphur dioxide, are condensed to a liquid in a condenser. The condenser is shown diagrammatically in **1**. It consists of a long coil of tubing surrounded by water, which absorbs the heat given out by the gas as it liquefies, the warm water passing away, and being constantly replaced by fresh, cold water. The liquefied gas now passes on through a regulating valve to the evaporator, where it rapidly evaporates, the liquid being converted again into vapour; in doing this it absorbs heat from the brine surrounding it, so that the latter is cooled down to a low temperature. The gas, as it leaves the evaporator, passes again to the compressor, and the cycle of operations is repeated. Provided there are no leaks, no fresh gas is required, since it is used over and over again.

The Chief Gases Employed. Opinions differ as to the most suitable gas, but we may mention three which can be used—namely, carbon dioxide (carbonic anhydride), ammonia, and sulphur dioxide gases. Carbon dioxide gas is cheap, costing only a few pence per pound. On the other hand, ammonia has the advantage that it is liquefied at a lower pressure. While carbon dioxide requires, in temperate climates, a pressure of 850 lb. per square inch for liquefaction, ammonia may be worked at a moderate pressure of about 120 lb. to the square inch. On the other hand, all compressor parts of the carbonic acid plant are much smaller. Ammonia is an alkaline gas, and in the presence of air will dissolve copper and other metals, so that in ammonia machines all copper, or copper alloy, must be avoided in any parts which come in contact with the ammonia. This is a great drawback to the use of ammonia machines where only sea-water is available for cooling, as the iron pipes, which alone can be used, are quickly corroded by sea-water. If it should escape, the smell is objectionable, though scarcely unpleasant, and in case of a serious escape it would prove dangerous. Sulphur dioxide is, perhaps, the least suitable of all three. It is not difficult to liquefy, but is more corrosive, especially as it is liable to be converted, by oxidation, to sulphuric acid in the presence of air and moisture.

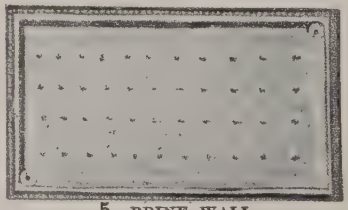


4. MARINE TYPE OF CARBONIC ANHYDRIDE REFRIGERATING MACHINE

In connection with cold storage we shall describe machines worked with carbon dioxide gas, but will treat of a machine using ammonia gas when dealing with the cooling of pasteurised milk.

Cold Storage Chambers. Figure **2** shows, in section, the construction of a carbonic anhydride refrigerating machine. Fig. **3** is an illustration of this machine, which, of course, can be used not only for cooling brine for cold storage chambers, but also for making ice, cooling water, or all purposes combined. It will be seen, as illustrated in **1**, that the compressor forces the gas into the coils of the condenser, which are contained in an annular vessel surrounding the evaporator, a space fitted with an insulating material being left between the two. The crank shaft not only works the compressor, but also a small pump, which drives the cooled brine from the inner vessel, and causes it to circulate through the pipes in the cold storage rooms. These brine tubes are made in long lengths, sometimes 200 ft., electrically welded, and are known as grids [**6**]. In large installations, the brine grids are divided into sections, each section having a separate return pipe back to the machine, where valves are placed for regulating the quantity of cold brine circulating in each section as required by the temperature in the room; a system of this kind is necessary in order to obtain a regular temperature in the cold stores. The grids are generally fixed at the top of each room under the ceiling, and, the air in contact with the pipes becoming colder, and consequently heavier, descends, and is replaced by "less cold" air from beneath, producing a constant circulation. Moreover, the air is not only cooled but dried, as the moisture separates out, and condenses on the grids. The quantity of cooled brine contained in the system of grids is very considerable, and this acts as a reservoir of "cold," so that in many cases it is unnecessary to run the refrigerating machine continually, but only for a few hours daily.

In some cases, especially when storing butter above 32° F, and all kinds of fruit, a circulation of cold air is preferable for cooling the chambers, in which case a number of grids are placed together in convenient proximity to the refrigerating machine, and air is drawn through them by means of a powerful fan, and conducted by means of air ducts to the cold rooms. In some meat-freezing



5. BRINE WALL

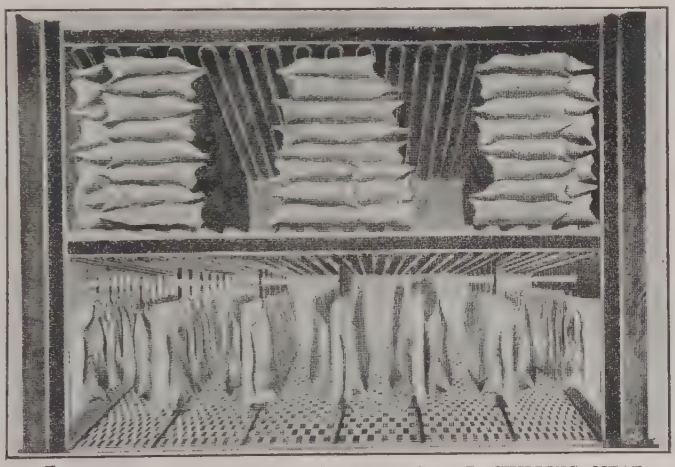
works it is the practice to install brine walls, which consist of large, flat, very shallow boxes [5] made of steel plates placed parallel to each other at convenient distances, through which the cool brine is circulated. In the passages between these walls the meat to be frozen or chilled is hung, as illustrated in **7**. The brine grids are seen beneath the ceiling, and the brine walls between the rows of carcases. In the rooms overhead, fitted with brine grids, the frozen meat is stored. The brine system is also largely used for bacon curing. The sides of bacon are hung up in rooms chilled by brine pipes, and generally with cold air circulation to 40° F., which temperature minimises the tendency to putrefaction, while, on the other hand, it is the lowest temperature at which the meat will "take" the salt perfectly. Fruit can also be very advantageously stored in cool chambers, either for carriage over long distances, or to keep back a glut until a time at which it will fetch a considerably enhanced price.

6. BRINE GRID

Refrigeration in Factories. Another instance in which refrigeration may usefully be applied is in cooling chocolate, in order to hasten and facilitate the removal of the tablets from he moulds. This is a very difficult operation in summer under ordinary conditions, when the chocolate tends to adhere to the moulds, making it necessary sometimes to remelt and cast again.

Brewing is a delicate operation depending on the growth of yeast, which is much influenced by temperature. A refrigerating machine is therefore of great importance in a brewery, where it is used to cool a large quantity of water for refrigerating the "wort" and maintaining the correct temperature in the "tuns." Moreover, the finished beer should be bottled at a low temperature.

Multifarious as are the uses of cold storage on land, it is, if possible, of greater importance in the shipping of frozen meat from our Colonies. For such purposes large marine-type machines are employed, as shown in **4**, while for preserving passengers' provisions the machines illustrated in **8** are used. The principle in all these machines is similar to that already described. Figure **9** shows a typical installation for the carriage of frozen meat on board a White Star vessel, on the system of Messrs. J. & E. Hall, Ltd., to whom we are indebted for illustrations **1-9**.



7. BRINE WALL SYSTEM OF FREEZING AND CHILLING MEAT

Preservation of Milk. We now come to another important application of the principle of refrigeration—the treatment of milk. There are very few substances which are commonly used for human consumption so susceptible to the action of bacteria as milk and cream. The rapid decay of these substances, which is commonly and popularly called "souring," is caused by the presence of micro-organisms. It is well known that "souring" goes on much more quickly in warm weather than in cooler weather, and it is likewise known that milk can be kept from turning for certain periods by being put "on ice," or in an ice safe. It is, of course, simply a case of arrested growth of bacteria; the organisms themselves are not destroyed by this action.

Pasteurisation. The process of pasteurisation, which may appear to be rather mysterious to persons not familiar with it, is a comparatively simple operation. In reality, it is a process of heating the milk or cream to a temperature that will destroy the disease germs and chilling it at once in order to prevent the spores from germinating and setting up another generation of micro-organisms. The rapidity with which these spores develop is astonishing, and the practical way of dealing with milk is to deal with it as quickly as possible after being taken from the cow, chill it down at once, and keep it at a low temperature. [See AGRICULTURE, pages 2943 and 3067.

Public opinion, combined with legal necessity, fixes the standard which the practical dairyman must attain, and the demands upon the dairyman are constantly becoming more and more severe.

There are, of course, difficulties connected with the process of pasteurisation, and they lie in the accomplishment of the desired result without injuring the milk or changing its consistency, for which machinery properly adapted to the purpose is essential. Properly pasteurised milk has been recommended by the best physicians.

The ordinary pasteuriser which has hitherto been used is shown in **10**, and consists more or less broadly of a vertical cylindrical vessel surrounded by a steam jacket. Within the vessel is placed a vertical spindle having a paddle or stirrer fixed to it, driven by suitable gearing from any source of power. The steam is turned on to the jacket, the milk allowed to flow into the machine, and the paddle set in motion. It is assumed that the whole of the milk becomes pasteurised in being rapidly stirred round and thrown against the steam-jacketed sides of the cylinder. Unfortunately, this assumption is not quite correct, as a portion of the milk does not come into contact with the heated sides of the cylinder, and passes away through the outlet without having

been raised to the requisite temperature to destroy the micro-organisms.

On the other hand, much of the milk is heated to too high a point, and coagulation of the albumen results, impairing the digestibility of the milk. Although the outflow from the pasteuriser may give the correct temperature of about 165°, it will be evident that some of the milk has been heated too much, and some insufficiently heated.

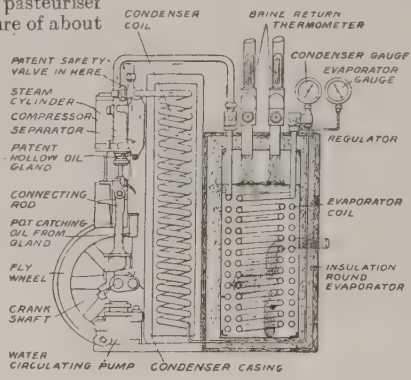
It should be mentioned that another drawback connected with the vertical pasteuriser with revolving spindle is that the step or joint upon or through which the spindle is situated forms a pocket where a little liquid is likely to remain, providing an ideal habitat for bacteria.

New form of Pasteuriser. In the newer type of machine the milk does not pass through a cylinder, and is not knocked about by a revolving paddle, but flows over a series of revolving drums which are semi-submerged in milk troughs.

In the case of the machine illustrated [11] the milk is allowed to flow slowly into the top trough, in which revolves a tinned copper corrugated drum, through which hot water passes at the requisite temperature. As the drum revolves, a film of milk adheres to it, and is carried over with it and heated to the right point. The outflow from the top trough is taken to a point where the heated milk naturally flows off, and none can go over excepting that which has been brought over by the revolving drum and properly heated. No milk can be overheated, and every particle of milk comes into contact with the drum without being churned or otherwise knocked about. In the second trough is a second revolving drum, through which ordinary water is constantly flowing. This water reduces the temperature of the milk to about 60°, and the milk then flows out into the third trough. A circulation of cold brine at about 35° passes through the third revolving drum, and reduces the milk to about 40°, at which point the milk flows out into a suitable receptacle.

In many modern dairies a cold-storage room at 38° to 40° is provided, and milk placed in it when it does not go out immediately for consumption.

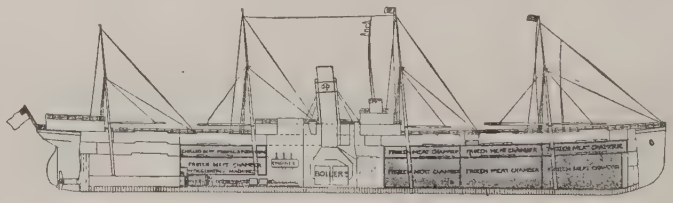
The revolving drums are made of hard rolled copper, tinned all over, and the milk troughs, which are round at the bottom, are made of the same material. There is, therefore, nothing that can contaminate the milk, and the revolving drums are thoroughly cleaned after use by being revolved while a brush is held against them, warm water being placed in each trough during the operation. This machine constitutes a pasteurising and chilling apparatus in one frame, but where the older types of pasteurisers are used the milk flows out from them over a flat cooler. These coolers reduce the milk to about 40° as it runs off into the large cans in which it is sent by rail.



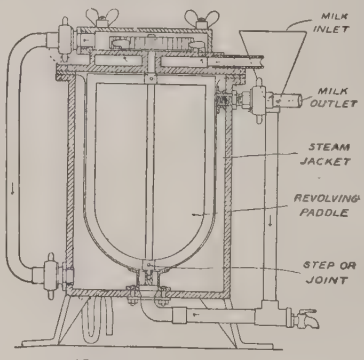
8. SECTION OF MARINE TYPE OF REFRIGERATING MACHINE

The Milk Refrigerating Machine. The next important item to consider in connection with milk pasteurisation and chilling plant is the refrigerating machine, which is necessary to produce brine at a low enough temperature to chill the milk to the requisite point.

We have already described machines worked with carbon dioxide gas. The one we shall now describe uses ammonia gas [12]. Any escape of gas is prevented by doing away with the reciprocating and compressor rod and stuffing-box, and by carrying the crank shaft horizontally through a self-sealing gland. The principle of refrigerating machines has already been explained. The gas enters at A through the pipe B, and thence into the piston C. D is the suction valve through which the gas passes as the piston descends; then, as it ascends again, the gas is compressed and driven through the passages F and up the discharge pipe F, into the condenser coils, HH, where it is cooled by the surrounding water and liquefied, collecting in a receiver. The liquid then flows to the expansion coils in the cooling apparatus, where it produces the desired refrigerating effect in the action of boiling off to gas again. The ammonia gas thus obtained is returned to the machine to be again liquefied, and the cycle is repeated.



9. SECTION OF A SHIP, SHOWING REFRIGERATING CHAMBERS



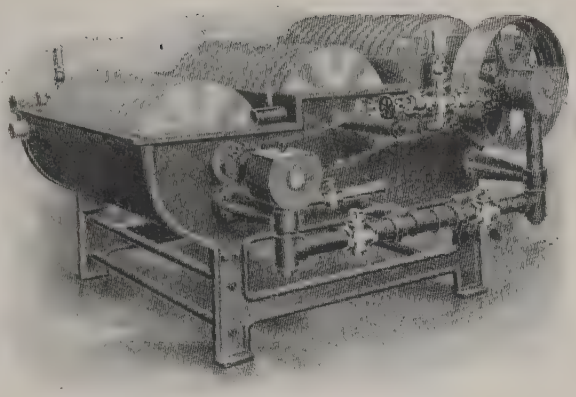
10. MILK PASTEURISER

The machine is actuated by the pulley P, attached to the crank shaft L, which revolves in an oil bath and also seals the packing joint M.

In larger machines the condenser is placed apart from the compressor, as a plant would otherwise be too bulky and cumbersome. It is built of two tubes, one placed inside the other; through the inner one runs the water which cools the ammonia compressed into the space between it and the outer tube. The construction of the coils is shown in **14**, and **13** is a view of the coil. This form of construction is far superior to the old type, where the ammonia gas was

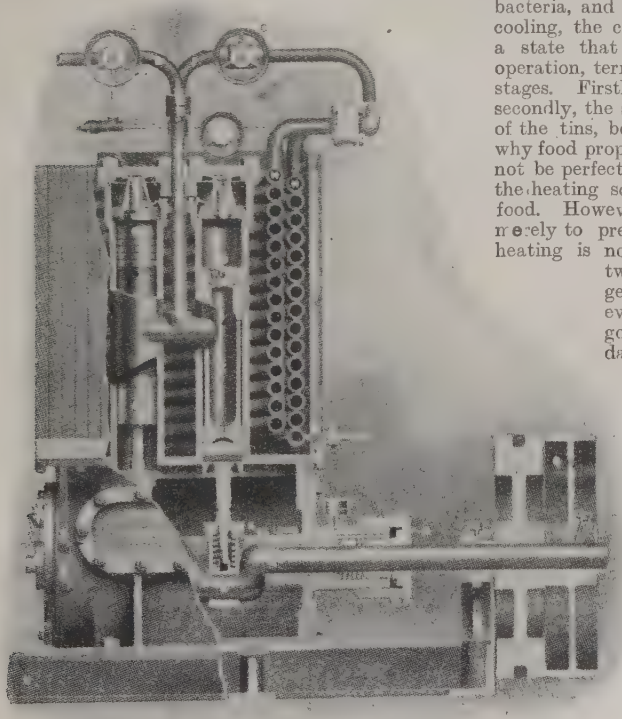
condensed in a flat coil of pipes, the gas flowing downwards inside the pipe and the water trickling downwards over the outside. The water in this case, being free to evaporate, brought about a certain lowering of temperature; on the other hand, the water getting warm in its descent ran over the bottom pipes when hottest, while the ammonia was endeavouring to liquefy inside these same pipes, with consequent re-evaporation of some of the liquefied ammonia and loss of efficiency.

The modern plant for dealing with milk mainly consists, therefore, of an efficient pasteurising machine and a simple and efficient refrigerating machine, with the necessary steam for the heating drum and the power to drive the pulleys on the pasteurising and refrigerating machines.



11. MILK PASTEURISING AND CHILLING APPARATUS
(The covers have been removed)

Removal of Dirt. Owing to the manner in which milk is produced, and at present handled at the farms, it seems almost impossible to exclude dust and dirt. An apparatus introduced within recent years is a strainer of exceedingly fine mesh, having about 1440 holes to the square inch. Such a fine gauze would be immediately stopped up if it were stationary and the milk simply poured through it. The strainer surface is therefore made in the form of a hoop, and is rotated as the milk flows through it. The rotating gauze hoop is constantly cleaned by a revolving brush, and passes under the milk in an open and clean condition. It is an established proof and fact that milk treated in the above-mentioned manner, properly cleaned, pasteurised and cooled, will keep about 18 hours longer under ordinary conditions than milk which has not been so treated. and it will keep in good condition for from seven to 10 days if placed in a cold room at 30°–40° F. The illustrations **10-14** have been supplied by Messrs. A. G. Enock & Co., Ltd.

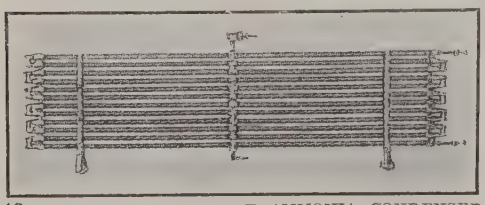


12. AMMONIA REFRIGERATING MACHINE

Tinned, Potted, and Bottled Goods. The method adopted in sterilising milk may be applied to numerous other foodstuffs. The principle of the canning process is simply this: The food is heated to about 170° F., in order to destroy bacteria, and the vessel sealed while hot. On cooling, the contents remain sterilised and in such a state that they will keep indefinitely. This operation, termed *processing*, is carried out in three stages. Firstly, the preparation of the foodstuff; secondly, the sterilisation; and, thirdly, the sealing of the tins, bottles, or jars. We know no reason why food properly prepared in this manner should not be perfectly harmless and nutritious, although the heating somewhat alters the character of the food. However, as it is the object of the packer merely to preserve and not to cook the food, the heating is not prolonged more than necessary, twenty minutes to half an hour being generally sufficient. There are, however, certain dangers common to canned goods. In the first place, there is the danger of the acid juices, especially in the case of fruits, having some action on the tin or solder, but cases of poisoning from this cause are very rare, and most of those recorded were probably due to quite another cause—namely, formation of ptomaines. At any rate, the danger can be easily avoided, if there be any, by using earthenware or glass vessels instead of metal ones.

Ptomaine Poisoning. The chief danger, however, arises from unsound tins, such as "pricked" tins—that is to say, tins inefficiently closed down, or which have been damaged so that the air has gained access to the contents. Tins are sometimes found "blown." This is owing

to incomplete sterilisation, bacterial action setting in after sealing, with the production of gaseous substances, causing a pressure inside the tin. There is always a partial vacuum in sound tins, so that when opened the air rushes in to them with a peculiar sound. If the tin has been imperfectly sealed, or if the sterilisation has not been complete, bacterial action is sure to set in, with the



13. COIL OF DOUBLE-TUBE AMMONIA CONDENSER

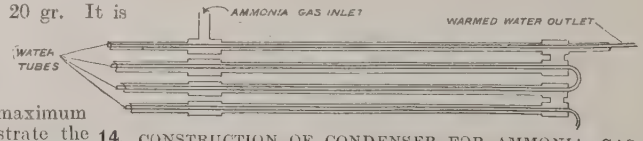
result that the extremely poisonous bodies, ptomaines, are produced. These are the causes of most cases of poisoning from eating tinned goods, especially tinned meat and fish, which are particularly liable to undergo such putrefactive changes. Sometimes, in the preliminary treatment, the foodstuff is treated with chemical preservatives in order to cover defective canning. This practice is to be condemned unhesitatingly, for if the canning be efficiently carried out there is no need for such preservatives. Chemical preservatives are, however, used very largely in food not destined to be canned, especially such as easily undergoes decomposition and putrefaction. We shall have to consider these chemical preservatives somewhat in detail.

Preservatives in Common Use. Common salt is about the oldest preservative we know of, but at the same time it is very ineffectual. In most cases large quantities are required. Where used it is often supplemented by the addition of some powerful preservative. Of chemical preservatives, borax and boracic acid are perhaps more commonly employed than any others. They are, however, very mild in their action, and the quantity used must not be too small. Numerous experiments have shown that less than 4 gr. to the pint is practically useless in preserving milk, and the quantity often recommended to be added is quite double this. Borax and boracic acid are also used largely for butter, cream, potted meat, and many other foods, and the question naturally arises whether they are harmful, and whether restrictions should be put upon their use. Boracic acid is frequently administered medicinally, the maximum dose being 15 gr.; that of borax is 20 gr. It is evident, therefore, that in the case of young children and invalids, who practically live on milk, the quantity taken daily, even putting it so low as 4 gr. to the pint, would exceed the maximum pharmaceutical dose. Such cases illustrate the danger which may attend its use. On the other hand, it is difficult to say how far it would affect a healthy adult, although elaborate experiments of Dr. Wiley some years ago seemed to show that even in that case it is likely to prove harmful. Nor can it be claimed that its use is necessary, as some of the largest wholesale dairymen bring their milk to London and other large towns from great distances, and manage to dispose of it without the use of any preservative whatever. Much the same considerations apply to butter, but we must bear in mind that it is not consumed to the same extent as milk by infants and invalids; and as to cream, the great difficulties in the way of preserving cream, even for a short while in the hot weather, make the use of a preservative pardonable. There is, however, no need for the use of any preservative in the case of meat or fish, which should be kept fresh by cold storage or other means.

Preservatives to be Avoided. Passing now to *formaline*, another preservative, we are on somewhat different ground. No one can assert that formaline is harmless, and its use as a preservative should be prohibited. Nevertheless, it is occasionally found in milk, and is sometimes sprayed over meat, fish, and fruit to preserve them. It has a peculiar action on the gelatinous constituents of foods, hardening them and rendering them insoluble, and thus very difficult to digest. *Salicylic acid* is another preservative, found especially in preserved fruits, temperance beverages, sacramental wines, lager beer, etc. It is probably more dangerous than borax, and its use is seldom, if ever, justified. People differ very much in their susceptibility to salicylic acid. Many people—according to some authorities, 60 per cent.—are easily affected by small doses of the drug, causing symptoms known as salicylism, including deafness, headache, delirium, etc. The use of salicylic acid in food should, therefore, be regarded with great suspicion. *Sodium sulphite* is another chemical preservative which is occasionally found, especially in stale meat, as it has the peculiar property of imparting the bright red colour of fresh meat. It also acts as a deodorant, and masks the offensive odours which are produced in the first stages of putrefaction. *Fluorides*, usually sodium or potassium fluoride, have been found in butter, and their use should be prohibited.

Frauds on the Public. With regard to all these chemical preservatives, the weaker ones, in small quantities, are not of very great value, and the stronger ones are dangerous. Moreover, their use must be regarded as a fraud upon the public, as they impart to the foodstuffs a deceptive appearance of freshness. Thus borax or boracic acid, although they have a certain inhibitory power on the micro-organisms, which bring about the souring of milk, probably have little or no effect on the more dangerous pathogenic bacteria, so that milk preserved with borax, although it may appear still fresh and palatable, is, nevertheless, as stale as if it had gone sour.

Unfortunately, legislation, as it affects preservatives, is extremely unsatisfactory in this country. Although the report of the Departmental Commission appointed to deal with this subject made



14. CONSTRUCTION OF CONDENSER FOR AMMONIA GAS

certain recommendations as to what preservatives should be permissible, and in what proportions, these recommendations have not been adopted by the Board of Agriculture, and have consequently remained a dead letter, with the result that conflicting decisions in the courts are the general rule.

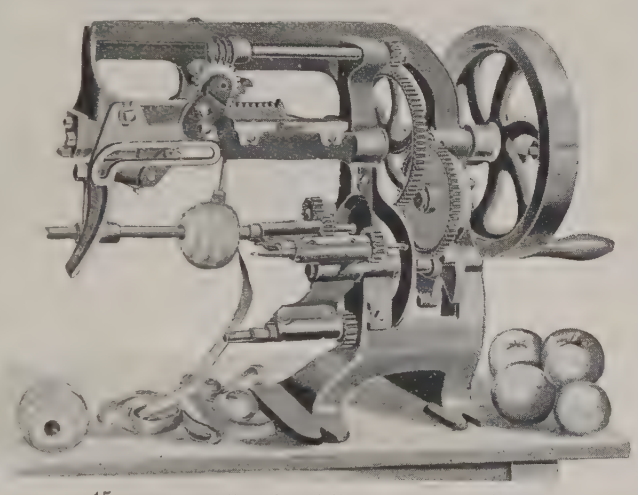
FRUIT PRESERVING

The importation of fruits into Great Britain, not deducting re-exportations, aggregates about 16 million tons, a good proportion of this quantity being used in making jam. To this supply must be added the fruit produced from the 84,000

acres devoted to small fruit growing in Great Britain, and which does not figure in any fiscal statistics. The number of jam factories in Great Britain is estimated at from 190 to 200, and this does not take any account of the quantity of jam, large in the aggregate, that is made in thousands of households, especially when fruit is cheap.

The Demand for Fruit. The public demand for fruit and preserves in enormous, and each year sees an increase in the acreage devoted to fruit-growing. The cultivation of apples for cider-making is also a growing industry, but the increase in acreage already alluded to is accounted for almost entirely by land devoted to other varieties of fruit. Jam-making is really the result of cheap sugar, and many of the larger factories have grown up within the last quarter of a century. The fruit imported into Great Britain comprises the dried fruits, such as currants, raisins, and prunes, together with fresh fruits, such as oranges, lemons, apples, and pears, fruit pulp, and candied fruits.

Oranges and Lemons. Oranges and lemons are the most easily marketed fruits. They come from the Mediterranean coast, China, the Azores, Mexico, Australia, and California. The oranges are gathered when not quite ripe, those fully formed and with the colour just turning from green to yellow being selected. Careful handling is essential, since rough handling results in bruising. The oranges are simply wrapped in fine paper or in the husk of Indian corn and put into boxes, the sides of which have air spaces. Lemons keep better than oranges, and are less liable to injury during the voyage. The greater part of the lemons grown are used as a source of citric acid.



15. NEW CENTURY APPLE-PARING MACHINE
Sprague Canning Machinery Co., Chicago

Currants and Raisins. Currants, the dried seedless fruit of a dwarf variety of grape vine, are produced in the Ionian Islands. The currants when sufficiently ripe are gathered and placed in layers exposed to the sun, being turned from time to time, and swept into heaps. When drying is complete the stalks have become detached. The currants are then separated from the débris and packed into casks for exportation.

Raisins are also a product of the grape vine, and are grown in Spain, Italy, Greece, the South of France, and California. The grapes are left on the vines after they have come to maturity, and the autumn sun is relied upon to do the necessary drying. Another way, and one practised in the newest raisin-growing districts, is to cut the bunches of grapes from the vine, and place them in shallow trays 2 ft. wide, 3 ft. long, and 1 in. deep. The raisins are then sun-dried, being turned from time to time by inverting a full tray on an empty one. The average time of drying is three weeks, depending, obviously, upon the weather. After the raisins have been dried they are stored in "sweat" boxes until ready for packing. To avoid delay in drying and any risk of getting the fruit wet through showers, some large growers have curing-houses, where the drying is finished after the raisins have been party sun-dried. Sun-dried fruit is far superior to that partly dried by artificial means. The drying-houses in use in Spain consist of a chamber 25 ft. long, 15 ft. wide, and 10 ft. high, the heat being supplied from a furnace outside, and conveyed throughout the building by a 9 in. flue. There is a vent for air at each corner. The temperature must not exceed 120° F., the most suitable for ensuring good fruit being 100° F. Some exposure to sunlight is absolutely necessary in drying raisins.

Why Raisins Look Glossy. In some parts of Spain and France the raisins are dipped, previous to drying, in a weak *lye* from wood ashes, to soften the skin and give the raisins a clear, glossy appearance. Drying is much facilitated by the preliminary dip in alkali. The dipping bath used for Valencia raisins is made by mixing the following ingredients: Wood ashes, 10 lb.; sulphur, ½ lb.; olive oil, ½ pint; water, 8 gals. Stir the ingredients together and allow to settle. The solution is then transferred to a cauldron, and heated to nearly boiling point before dipping the raisins. Occasionally, the dipping is dispensed with, the liquid being distributed over the fruit by means of a whisk. The method recommended by the Victoria Department of Agriculture for making pudding raisins is to dip the grapes, as soon as gathered, into boiling lye, made by mixing 1 lb. of Greenbank concentrated lye with 15 gals. of water. The fruit is immersed for from 20 to 30 seconds, the effect of the lye being to break the skin into minute cracks, and so facilitate the escape of moisture in the subsequent drying. The dipped fruit dries in from eight to twelve days in bright weather.

To give the fruit a bright amber colour, much preferred by the housewife, a sulphuring process is employed. The trays of raisins are stacked in a small chamber and exposed to the fumes of burning sulphur for from 40 to 50 minutes. The sulphuring has the effect of bleaching the dark colour, and increasing the value of the fruit in the market. Stemming (removing the stalks) and grading are performed by a simple machine, and two home-made wire sieves of ⅝ in. mesh and ¼ in. mesh answer perfectly when large quantities are not being treated.

Dates. Some varieties of dates require practically no curing, being ready to pack and ship as soon as they have ripened. Other varieties, however, need some preparatory treatment. Dates are borne in bunches, which have a single stem with numerous slender twigs, to which the fruit is attached. A bunch carries from 10 to 30 lb. of fruit. It is very rare that all the dates on a bunch ripen at the same time; and in the case of choice varieties, those which first ripen are often hand-picked, and shipped at once, in order to get the high prices paid for the earliest consignments. It is also claimed that picking the outer dates of the bunch, which usually ripen first, permits the inner fruit to ripen better. Frequently, when most of the dates on a bunch are ripe and the rest are beginning to ripen, the whole bunch is cut off and hung up in a dry and shady place. In a few weeks the whole bunch is ripe and ready for shipment. The choice varieties of dates are shipped from the Sahara, either in bags or long, wooden boxes, and afterwards repacked in smaller boxes. The above methods apply to the Deglet Noor variety, which is chiefly exported from Algiers. The Rhars variety, which is full of sugary juice, is not so easily handled. The Arabs usually hang up the bunches, and allow the juice to drain off into jars. This juice is called *date-honey;* and when it has drained off, the fruit is ready for packing into boxes or skins. When packed tightly, dates keep for years without any deterioration in quality.

Prunes. Prunes are simply dried French plums. The best kinds are sun-dried after careful selection for quality. The plums are allowed to ripen thoroughly before being gathered.

The alternative process used in some districts involves the use of a lye-bath, as for raisin-curing, to soften the skins and facilitate the drying. The softening in other cases is done by half cooking the dried plums for from two to three minutes in water to which glycerin, in the proportion of 1 lb. to 20 gallons, is added. The plums are then dried for three or four days, and then packed in glass bottles that are tightly sealed. The lighter-coloured prunes are submitted to a sulphuring process.

Figs. Figs come chiefly from Asiatic Turkey, though Portugal, Spain, and Greece send small quantities. The figs are allowed to drop from the trees; the fruit does not bruise, because it is dry. The figs are then exposed to the sun on dry grass for three or four days. Smyrna is the centre of the fig-producing district, the growers bringing in their produce in sacks. Damp is injurious in the drying process, and the pre-eminence of Asiatic Turkey is due to the climate being perfect for fig-drying. In Spain the climate demands that the figs must be covered up with boards or canvas during the night, or they would spoil.

Desiccated Fruits. Desiccated fruits include dried apples, apricots, and peaches. It is questionable whether the demand for dried apples is so large as formerly, as the preference is naturally given to the fresh apples now obtainable all the year round. Apples for tarts are now also to be had, at very reasonable prices, packed in water. The *dried apples*, or *apple rings* as they are called, have, however, the advantage of cheapness, and when rejuvenated by soaking in water are a really passable substitute for the fresh fruit. The apples are pared, cored, and sliced by machinery, one of the machines being illustrated in **15**. As soon as peeled, the apples are dropped into salt water, and after a few minutes' immersion are put in the sulphur-box, and fumed for from 30 to 35 minutes. The slices are then spread on trays, and placed in the sun for four or five days, being turned once. When artificial drying is employed, a chamber or evaporator supplied with a current of air at 240° F. is used. The trays of apple slices are taken through the evaporator on an endless chain, moving every three or five minutes. A bushel of apples makes 5 lb. of dried fruit. *Apricots* and *peaches* must be thoroughly ripe and well coloured before being gathered. They are then pared, halved, and stoned by simple appliances, and placed on wooden trays, cut side up. Drying takes five or six days in the sun, and is often preceded by sulphuring. As neither of these fruits is grown in Great Britain to any extent, there is considerable demand for the dried articles. Passable jam can be made from dried apricots, the proportions being 2 lb. of dried apricots, 5 lb. of sugar, and 8 pints of water. The apricots are covered with water for five minutes, and drained, 8 pints of water being then added, and allowed to remain in contact for 12 hours. Next transfer to an enamelled pan, boil for five minutes, add the sugar, again boil for fifteen minutes, and put into pots.

Canning and Bottling. Canning fruit is distinctly an American process. The English term would be *tinning*, but as the association of a metal with a food is apt to convey a bad impression, it is perhaps as well that the American term *canning* is used. Bottling of fruit is, of course, merely a development of canning, the primary reason doubtless being that glass is supposed to be preferable to tin for food containers, which, however, is not the case, for the lacquer with which the insides of the tins are coated renders them perfectly free from any danger of affecting the fruit or syrup or water in which it is preserved. The underlying principle of canning and bottling fruit is that the contents are sterilised, and then preserved in a hermetically sealed vessel. The temperature of 170° F. has been found to be the correct one to use in sterilising, but the time taken for this temperature to penetrate to the centre of the vessel containing the fruit naturally varies according to the size of the vessel and the kind of fruit which is being sterilised. The fruit must not be heated sufficiently long to cook it; hence care is necessary in the temperature employed, if successful bottled or canned fruit is to be produced. The "A. B. H." thermometer is used to ascertain the sterilisation point of the interior of a bottle of fruit. A similar thermometer is also applied to cans. Fruit is canned in either water or syrup. If syrup be employed, it is poured over the fruit as it boils, and consequently the time taken for sterilising is shorter. The general formula for canning fruit is as follows: Carefully select and prepare the fruit, place in the tins, and cover with cold or boiling water; seal the tin so that it is air-tight, and sterilise (or *process*, as canners generally call it). The average times are: For small fruits, such as cherries and small plums, pint size cans, 8 minutes; quart size, 10 minutes. For large fruits, such as peaches and apricots, pint size, 10 minutes; quart, 12 minutes. These are for fruits with the stones left in. When the stones have been removed a shorter time is required, as the heat is conveyed to the interior more quickly—for pint cans, 6 minutes, and for quarts, 8 minutes, are average times.

Preliminary Treatment for Preserving. Apples and similar fruits require paring and coring, as for making dried apples, but are

not sliced. Pack as tightly as possible in the containers, fill with boiling water, seal and process. The time required is that given for stoned fruit. A difficulty met with in canning apples is the discoloration of the fruit. To obviate this, some makers put the apples, after peeling, into a solution of sodium sulphite (1 oz. to 4 gallons of water), or a solution of alum of the same strength. When syrup is used, it is of the strength of 18° B., and is often flavoured with lemon.

Pears are treated in a similar manner to apples, but are often more difficult to keep white. If the result desired be not obtained by the treatment given above for apples, the peeled and cored pears are exposed to the gas given off from burning sulphur for three or four hours.

Cherries have their stones removed by means of a *pitting* machine, are then put into bottles, covered with water, sealed, and processed. The cherries used should not be ripe, and the water for filling the bottles is generally coloured with cochineal, as the public prefer a brightly coloured product.

Greengages are pricked to prevent bursting, a silver or copper needle being employed. The water is often tinted green with a little emerald-green. Plums are pricked, but no tint is needed.

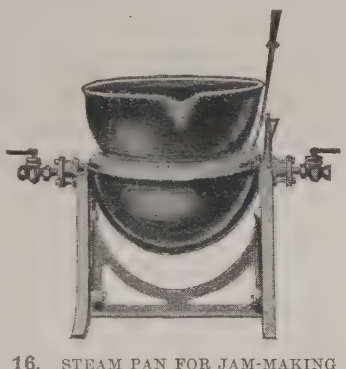
Gooseberries are bottled when green.

Apricots and peaches are cut into halves and pricked, the stones also being removed. Syrup is always used for these fruits. Whole apricots are also canned.

Rhubarb is bottled when tender and young. It is cut into pieces about 1½ in. long. Water is used in the bottles.

Bananas are bottled in syrup to which glucose has been added in place of sugar. The syrup is generally flavoured with vanilla or lemon, and to improve the taste a little citric acid is added.

Red currants are removed from the bunches with a nickel, silver, or celluloid comb.



16. STEAM PAN FOR JAM-MAKING
William Brierley, Rochdale

Blackberries require very careful picking over to remove leaves and refuse. For this purpose they are spread out on a table in front of the operator, a good light being essential.

Raspberries and strawberries are not often successfully canned unless they have been previously candied—that is, if it is desired to retain their shape. The big preservers, who have expensive plants and particular facilities, are able to can and bottle the fresh fruit.

Pineapples are peeled by machinery and sliced, care being taken to remove all the "eyes." This fruit takes two hours to process, at the temperature of boiling water, on account of its bulk.

Crushed fruits, so much used for soda-fountains in the United States, are prepared by crushing or grating the fruit, which is then heated with boiling syrup at 28° B. for three minutes, then transferred to tins or bottles, and processed for a time varying from 10 minutes for pint containers to 40 minutes for gallon tins.

Pulping. Fruit pulp is fresh pulp preserved without sugar; it is, in fact, a sterilising process of keeping fruit. Large quantities of fruit pulp are imported into Great Britain, and used for making jam. All the apricot jam made in Great Britain is necessarily made from imported apricot pulp, as but few apricots are grown in this country. Pulped fruits are a little inferior to ripe fruits for jam-making, and hence pulps are only used in medium and cheap jams. The difference, however, is mainly in appearance, and does not affect the wholesomeness of the product. The addition of colouring matter to jams made from pulps is required to give a nice appearance. A great deal of fruit pulp of various kinds is imported from the Continent and from America.

The process of fruit-pulping is, in outline, to add 32 oz. of water to 20 lb. of the fruit, boil for five minutes, put into gallon or two-gallon tins, and process for from 2½ hours to 3½ hours (for gallon tins) at the temperature of boiling water. The tin should be lacquered to prevent possible metallic contamination and discoloration of the pulp.

Apricot pulp is made from ripe fruit which has been stoned, and a little more water is added than is given in the outline process above. The stones from the apricot are used for flavouring purposes, and should not be thrown away. Peach pulp is similarly prepared. Greengages are stoned, and in the preliminary boiling should not be violently stirred, as the fruit would be broken up too much. Cherry, strawberry, and black currant pulp present no difficulties, except that in the case of strawberries the preliminary boiling is limited to two minutes, on account of the soft nature of the fruit.

Jam-making. Jam is usually described as a conserve of fruit boiled down with sugar. There is no standard for jam. Each jam-maker has his own modification of the old formula —1 lb. of fruit to 1 lb. of sugar —the test of a good product being the appreciation of the purchaser. It is, of course, understood that wholesome ingredients must be used in every case. The employment of wet or damaged fruit for jam-making brings in its train a multitude of consequences which soon injure a jam-maker's reputation. The solidifying property of jam is due to the sugar and to the pectose contained in ripe fruit. The pectose, by boiling with vegetable acids, such as are also contained in the fruit, yields a product known as *pectin*, which possesses solidifying power like gelatin. Prolonged or violent boiling destroys the pectin, and hence impairs the solidifying powers of the jam. On the large scale, steam pans [**16**] are used.

The general formula given above is the one on which the manufacturer founds his process, except that the boiling, which in the case of domestic manufactures may be up to two hours, is by steam pan process cut down to 15 or 20 minutes, the product being superior, as regards flavour and appearance, to the domestic article. Crystal sugar, equal in quantity to the fruit, is added, the mixture being boiled to dissolve the sugar. The contents of the pan are stirred, and if glucose be used it is added in place of part of the sugar. The second or medium grade jam is made from fruit pulp, and a cheaper grade still is made by boiling fruit pulp 100 lb., sugar 30 lb., and glucose 70 lb., till dissolved, and adding towards the end of the process 1 lb. to 1½ lb. of agar-agar dissolved in the smallest quantity of water. The jam is poured into the earthenware

or glass pots direct from the pan, and when the product has set the surface is covered with a disc of waxed paper, previously dipped in spirit. The wet parchment cover is stretched over the top, and fastened so as to exclude air.

The Making of Special Jams. Strawberry jam is made from the freshest fruit, for if the strawberries stand over-night the colour of the jam is not so good. The Wisbech district, Kent, and Cornwall are the strawberry-growing parts, the Cornwall strawberries being the earliest in the market. Raspberries are grown extensively near Yarmouth and at Blairgowrie. The crop of raspberries of late years has been poor, but it may be mentioned as a hint to growers that in Scotland the favourites are Maclaren's Prolific and the Red Antwerp, while farther south the best varieties to grow are Superlatives, Carter's Prolific, and Semper Fidelis. Raspberry jam is a difficult one to set, and for this reason a portion of gooseberry or apply jelly is often added to it. Black currants come in large quantities from France, Holland, and Belgium; and on account of the ravages of the black currant "mite," imports of the fruit are necessary to meet the demand. Blackberries are preserved with apples, and such jam is in increasing demand. The blackberry crop is a difficult one to get picked, and fetches from £10 to £20 a ton. As regards plum jam, although plum pulp is not imported, for reasons stated above, immense quantities of plums reach this country from the Continent, in seasons of scarcity coming even from so far afield as Hungary. French and German plums come in some three weeks before the English plums are ripe for the market, but are not superior to English fruit. The advantage which foreign fruit enjoys over home grown is that large quantities of a particular kind of plum—such as the Zwetchen—can be obtained, whereas the English plums are from various kinds of stock. When home-grown plums are plentiful the foreign article cannot be profitably imported, as it costs £7 10s. a ton to import foreign plums, and an English grower is satisfied to get £7 in times of plenty. Greengages nearly all come from Cambridgeshire. Damsons are very largely grown near Wrexham for jam purposes; and although the popular taste has shifted from damson to plum jam, there are still large quantities of damson jam sold in Lancashire.

Kind of Sugar Used. In manufactured jam there is about 55 per cent. of sugar. The sugar may be either the product of the sugar cane or the beet. [See SUGAR.] There is practically no difference in the respective values of these sugars, so that the cheapest should be used. Glucose was for a time used by many jam manufacturers, but there is now a popular prejudice against it, and it is used only in the common kinds of jam. When sugar is boiled with a weak solution of a vegetable acid, it is changed into "invert" sugar, then into dextrose and levulose, and finally into glucose.

Jam Colouring. As has been noted in the section devoted to pulping, the colour of the product is impaired, so that when made into jam a colouring matter is needed. Pink is obtained by the use of carmine (the active principle of cochineal), and a wine-red by means of cudbear.

Aniline dyes, rhodamine, and rosaniline are sometimes used, the quantity needed being but 5 or 10 grains in a hundredweight of jam. The colour is added in solution during the early part of the process of jam-making. As yellow colours, sometimes added to apricot jam, saffron-yellow and auramine (aniline dyes) are used. In regard to the use of preservatives, salicylic acid is employed in the proportion of ½ oz. to 1 cwt. of jam. It is added in the form of powder at the beginning of the process, the boiling of the jam being sufficient to ensure mixing. Owing to the minute quantities of the aniline dyes required, no harm results from their use.

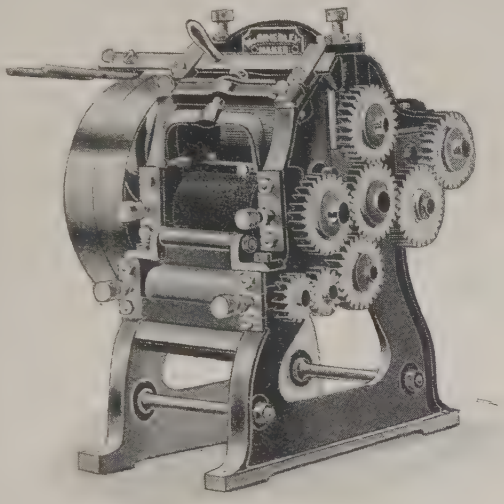
Fruit Jellies. Fruit jellies are transparent preparations of the juices of fruits, and are used to supply or make good the deficiency of the setting power of raspberry, strawberry, and black currant jams. Some jellies are, however, largely used in place of jams, while red currant jelly has a special purpose in the cuisine as an adjunct to roast mutton and hare. The fruits from which jellies are mostly prepared are apples, gooseberries, grapes, black and red currants, and blackberries. The process is to mix three parts of fruit with one part of cold water, and boil. The mass is then transferred to filter bags, and the juice is finally heated to boiling point and poured into stone jars which have been previously scalded to destroy fermentation germs. Fruit jellies are made by adding to each pint of juice a little over a pound of sugar, and boiling till a small quantity of the product, removed and cooled on ice, sets to a jelly.

Marmalade. Marmalade is an orange jam, although originally the name was applied to a quince jelly, *marmelo* being the Portuguese for quince. It is now rarely made from quinces, but oranges, lemons, and grapes are used. Originally, marmalade was made with honey, but now sugar is the base employed. Orange pulp is imported from Spain for the use of marmalade makers, but all the best manufacturers use the fresh Seville oranges. Machines are sold for the special purpose of cutting up the orange and lemon peel. A good *domestic marmalade* is made by using both bitter and sweet oranges with lemons. For instance, six bitter oranges, three sweet oranges, and two lemons may be taken, the peel removed, with a minimum of white, cut up, and boiled with nine pints of water until soft. The rest of the fruit is pulped and the juice expressed, and in the mixture of juice and peel infusion 9 lb. of sugar is dissolved, and the whole boiled until jellying takes place on cooling a little of the mass. For making marmalade on the large scale, oranges are peeled, freed from pips, the peel sliced and cut up in pieces by a machine [17], and the rest of the orange reduced to a pulp; to 20 lb. of this pulp are added 30 lb. of sugar and ½ gallon of apple juice, the cut-up peel introduced, and the whole boiled slowly for an hour. After this further boiling is given at a more rapid rate till the product jellies on cooling. It is obvious that the oranges may be mixed, as in the recipe for domestic marmalade. *Orange marmalade* of the jelly class is made by excluding the orange pulp, using only the juice. A French recipe is as follows: Orange juice, 5 pints; apple juice, 15 pints; syrup, 10 pints; sugar, 5 lb.; finely sliced orange-peel, 5 pints. These ingredients are boiled together till the marmalade sets to a jelly on cooling. *Grape marmalade* is really a fruit jelly, and is made according to the method described in the section devoted to fruit jellies.

Candied Fruits. Candying is a refinement of the preservers' art, and is applied to cherries, strawberries, greengages, small oranges and pears, to lemon, orange, and citron peel, and to angelica. The fruits are prepared as for bottling, and finally dried on trays made of white willow. A stoneware tank is employed, the fruits being packed in it

and covered with weak syrup. After being in the syrup overnight the syrup is withdrawn by means of a stopcock at the bottom of the tank, and concentrated by boiling and adding more sugar from, say, 20° B., at which it was used first, to 22° B. This syrup is then poured over the fruit and left for two or three days, drained off, and again concentrated, the process being continued till the syrup registers 33° B., when it is drained off and the fruits taken out and dried slowly in a warm room. Finally, if the fruits be not covered with fine crystals of sugar, they are crystallised by pouring over them, on a wire tray, a syrup of 33° B. strength, made from pure sugar, drained and dried. *Glacé fruits* are produced by giving the fruits at the end of the syruping process a few minutes' boiling in syrup and removing them to a wire tray to dry slowly. A small proportion of glucose may be added to the syrups used in candying fruits, and colouring matters may be introduced if needed. A hot process is also employed, in which the fruits are boiled with the successive syrups. Besides being eaten for dessert, candied fruits are used for preparing superior kinds of jam. Candied strawberries and raspberries are excellent when made into jam with apple juice. Candied cherries are covered with maraschino-flavoured spirit to make "cherries in maraschino," and Wiesbaden fruits are candied fruits put up in strong syrup. For testing the strength of the syrups a hydrometer is used.

The Factory. The ideal arrangement of a factory is such that the workmen are kept employed all the year round. Hence, factories which make jam should can vegetables and make pickles, etc., to fill in slack months. It is consequently difficult to give trustworthy estimates of the cost of equipping a factory until the extent of the trade to be done is stated. The machinery for a small factory costs anything from £200 upwards, according to the branches of canning pursued and the amount of business done. Some of the costs of machinery used in canning are stated below, to give an idea of the expenditure in fitting up a factory.



17. HOME-MADE MARMALADE MACHINE
William Brierley, Ltd., Rochdale

Copper steam-jacketed jam-boiling pans, suitable for working at a pressure of 70 lb., and with a capacity of 45 gallons, cost from £17 to £35.

Tanks for bottling fruit are made of iron with false bottom for standing the bottles on, under which is the heating coil. The cost of a tank 7 ft. long, 2 ft. 9 in. wide, and 18 in. high is £16 16s.

Apple-paring machines cost £1 10s. to £5, according to the pattern. An *apple slicer* of simple design costs 16s., the more complicated varieties running to £15.

A *marmalade machine* for stripping the white from orange-peel and cutting into strips costs from £15 to £50. A *pulping machine* for fruit costs from £10 10s. to £40.

A *hydraulic press* for extracting the juice from apple pulp by hand power entails an outlay of £50; for £5 extra it can be adapted to power.

Platform scales for weighing large quantities of fruit or sugar cost from £2 to £10.

Horizontal boiler complete costs from £100 for a 10 h-p. boiler.

Hydrometers for testing the strength of syrups cost 4s. 6d. each.

Thermometers for taking temperature of water, etc., cost 10s.

Factory trucks cost from £1.

Hoist, of a capacity of 1000 lb., costs about £15.

Soldering irons cost from 3s.

Peeling knives cost 3s. 6d. a dozen.

CONDIMENTS

Although eaten with foods, condiments cannot be regarded as true foods, as their food value is almost negligible, many (such as pepper, mustard, and spices) being largely composed of indigestible fibre. They may, however, be regarded as adjuncts to food, and are taken in comparatively small quantities, with the idea of stimulating the appetite. Most of them contain a small proportion of a very active ingredient. Thus pepper contains a resin, "piperin"; mustard, a volatile oil; and spices similar oils, which give to the condiments their peculiar flavours. These active ingredients are so powerful that they would act as poisons if taken in really large quantities. Acetic acid, too, can only be taken in the diluted form as vinegar. In virtue of the chemical nature of the active ingredients, many condiments act as food preservatives, especially salt and the spices.

Common Salt. Although most condiments can hardly be regarded as necessities, common salt is certainly an exception. It is one of the essentials for our health preservation.

Nature has endowed this country with salt supplies second to none, both in quantity and quality. Salt is brought to the surface either in the form of clear liquid, as *brine*, or as dry rock, known as *rock salt*. Cheshire brine yields for every imperial gallon 3 lb. 2 oz. of dry salt. Roughly, 1000 gallons of brine produce a ton of dry salt.

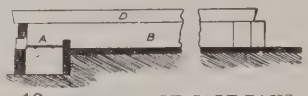
The brine is said to run under the earth in channels, and to collect in the lowest part of the geological basin at a depth of about 130 ft., whence it is pumped to the surface. It is supposed to result from the rain-water percolating to the rock salt and dissolving it. Where fresh water reaches the surface of rock salt, either at the outcrop or through fissures in the outlying marl, brine is formed.

The brine has the following average composition :

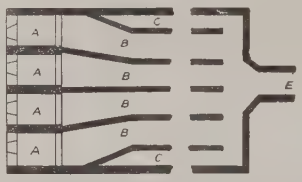
Substances	Northwich	Droitwich	Stoke Prior
	Per cent.	Per cent.	Per cent.
Sodium chloride ..	25·222	22·452	25·492
Calcium sulphate ..	·391	·387	·261
Sodium sulphate ..	·146	·390	·594
Magnesium carbonate	·107	·034	·034
Total solids ..	25·866	23·263	26·381

Brine is pumped by two plungers from a depth of 64 yds. through an 8-in. pipe, and delivered to an enormous wooden cistern measuring about 36 ft. by 32 ft. by 10 ft. deep. From this tank the brine passes through pipes to the evaporating pans.

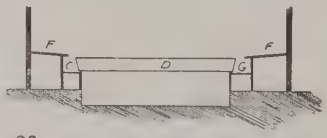
The Salt-pans. The pans are made of steel, measuring about 36 ft. by 24 ft. by 20 in. deep, rest on brickwork, and are heated underneath by coal fires. A battery usually contains from five to ten pans. For examples of ordinary pan settings, see **18, 19,** and **20.** This type of pan has one flue, B, for each fireplace, A, and blank spaces, C, over which the salt in the pan can be scraped to the side without fear of overheating. D is the salt-pan, and E the flue to drying-room ; F F the hurdles, and G the floor, on which the workman stands. Each pan in the particular works we are describing has two fires, divided by a partition wall running half way to the back of the pan. In order to ensure even distribution of heat, there are five draughts, as they are called, divided by four parallel walls running half way from the back. Brine is conveyed continuously to the evaporating pan, gentle ebullition takes place, and enormous volumes of steam pass off from the surface and disappear up the ventilators in the roof. The temperature of the brine is maintained at about 220° F.



18. SETTING OF SALT-PANS
(Longitudinal section)



19. PLAN OF FLUES OF SALT-PAN



20. TRANSVERSE SECTION OF SALT-PAN

As the water evaporates, an incrustation of crystalline salt is formed on the surface, which, as it gets heavy, settles in the cooler end of the pan. The crystalline deposit of pure salt so formed is drawn to the side of the pan by means of a rake [**21**]. The salt is then lifted out of the pan by means of a skimmer [**22**], a perforated scoop about 18 in. diameter. The excess of liquid drains through the perforations, and the contents of the skimmer are transferred to a wooden mould consisting of an open box [**23**] tapering from one end to the other (length, 22 in. and 8 in. by 8 in. at large end), standing on its smaller end.

21. RAKE **22.** SKIMMER **23.** MOULD

Drying and Packing the Salt. When a number of moulds have been filled and allowed to set, they are inverted, tipped out, and conveyed to the drying-room. The ordinary size block weighs 28 lb. (80 to the ton). Each pan produces four tons in 12 hours (equal to about 50 tons a week).

The drying-room is heated by the waste heat from the furnaces, which passes through long, square, iron flues, 4 ft. by 4 ft., placed on the floor level, on and around which the blocks are stacked. The temperature of the drying-room varies from 120° F. to 150° F. The blocks take six to fourteen days to dry, according to the temperature and weather. The dried blocks now pass through a munching machine, and then through a pair of rollers, and finally through sieves, until the required grain of salt is obtained.

The dry salt is carried by "elevators" to the top of the building, whence radiate, octopus-like, shoots or feeders, reaching to all parts of a large packing-room, where girls are busily employed filling *damp*-proof paper packets, which consist of two sizes, and contain 1½ lb. and ¾ lb. respectively of table salt. The salt is never touched by hand from beginning to end.

Preparing Fishery Salt. The preparation of salt for the preservation of food, such as fish salt, is made somewhat differently from that of table salt. It has to be coarse and distinctly granular for sprinkling between layers of fish in boxes or barrels, as, if too fine, it would melt too rapidly.

For *fishery* salt, the brine in the pans is evaporated at from 90° F. to 120° F., according to the quality to be produced. The lower the temperature, the slower the operation, and, in consequence the coarser the grain.

There are several qualities of fishery salt, distinguished according to coarseness. The first grade of salt is named Second Fishery, a degree coarser is Best Fishery ; next higher grade is X Fishery ; a still better quality is XX, and the highest of all, and the coarsest, is Bay Salt [**24**].

From 22 to 25 tons per pan per week is the average production of fishery salt.

The Salt Union supplies 90 per cent. of the salt used in Great Britain for fish-curing. The pans owned by them have a capacity of about 1,000,000 tons per annum.

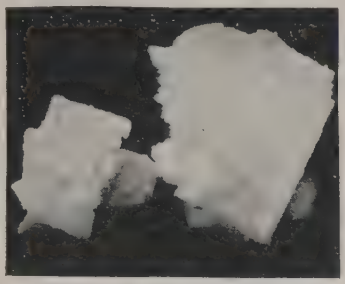
The attempt to oust the pure, natural article by salts obtained from sea-water evaporated by the sun's rays in hot climates is likely to end in failure, as, in addition to the great inferiority in composition of the latter, there is a liability to the formation of a fungus on fish which does not take place with the pure article. Sea-water also contains many organic ingredients that militate against the proper preservative action of salt.

The following analysis will show the difference in composition between the Cheshire fishery salt and the foreign sun-evaporated sea-water :

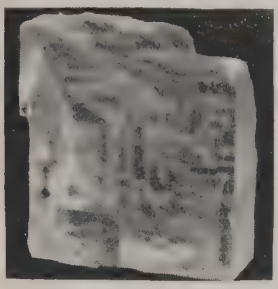
Ingredients	Cheshire Second Fishery	Foreign
	Per cent.	Per cent.
Chloride of sodium (pure salt) ..	97·32	89·21
Moisture	1·72	4·82
Sulphate of lime	·85	1·48
Sulphate of magnesium	—	3·15
Chloride of magnesium	·08	·95
Insoluble matter	·03	·39
	100·00	100·00

Where Rock Salt is Found. The geological position of rock salt occurs between the coal formation and the lias in the New Red Sandstone of the Triassic series. The great rock salt formation of England occurs within the red marl, or red sandstone. At Northwich, in the valley of the Weaver, rock salt is found in two chief beds, the top being about 87 ft. thick, and the bottom 90 ft. The top bed is 126 ft. below the surface.

The mining is done from the bottom of the layer of the thick bottom bed, where the best salt is found. The natural beds are about two miles long by one and a half miles wide.



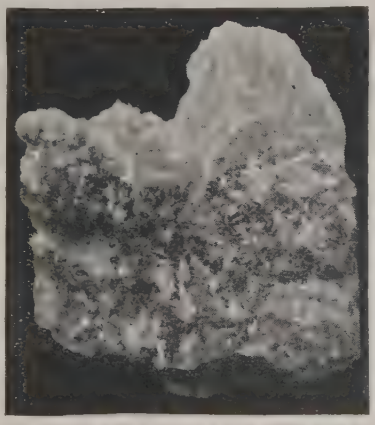
24. BAY SALT
(One-third scale)



25. SALT CRYSTAL
(Adelaide mines, one-half scale)

A Large Salt Mine. To support the weight above, it is necessary to leave pillars of salt equal to about one-twelfth the area of the mine. This is done by leaving enormous pillars (somewhat larger at the bottom than the top), 10 yds. square and 25 yds. apart.

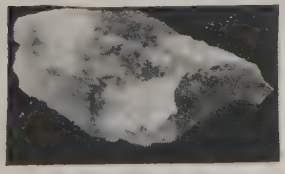
The rock salt raised as blasted from the Adelaide mines belonging to the Salt Union, Ltd., at Marston, Northwich, is called "Prussian Rock" when brought to the surface, and the larger pieces resemble enormous blocks of granite and porphyry. In places it contains veins of deep brown or amber colour [light portions, 26], grading to pale transparent salmon tint [dark portion, 26], and in some parts it is as transparent as glass and very pure, and crystallised in large cubes [25]. If taken at base of vein, one occasionally finds attached pieces of stone [see right-hand bottom corner of 27]. In other places the caverns are bristling with needle-shaped crystals not unlike the familiar sal-ammoniac [28], and in some few places it is opaque and white, falling to pieces between the fingers as though Nature had already prepared it for coarse fishery salt [29]. The mine at Marston is 336 ft. deep. It is approached by a perpendicular shaft about 9 ft. wide, by means of a bucket, which emerges into a cavern 30 ft. high. This cavern is the largest rock mine in Great Britain. Its walls and domes are bristling with crystals of rock salt in the various varieties referred to above. This chasm has entirely resulted from the removal of enormous quantities of salt rock, about and around which there still exist almost limitless supplies.



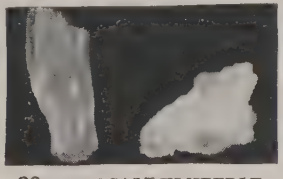
26. ROCK SALT FROM ADELAIDE MINES
(One-third scale)

The Mining of Rock Salt. In order to obtain the rock salt, a horizontal incision is made in the wall of the rock 7 in. from the base, the incision being 4 in. deep and 28 in. wide. This is performed by a machine resembling a very substantial circular saw with two-way teeth arranged round its circumference. The machine is driven by compressed air laid on to the mine, and is moved forward by means of a grab. The cut it made slightly downwards, so that the floor appears in ridges. The progress of the work depends largely upon the hardness of the rock, which varies considerably at different points. To prepare the rock to receive the charges for blasting, holes are produced by means of an iron pole, called a *chisel*, that is rod-shaped and tapering towards the end, which is beaten out to a spear-shaped head. This is thrust into the rock and turned until the required depth is reached. In this hole a charge is inserted and fired by the aid of a fuse. Sometimes the charges merely crack the rock, and at others they remove several tons. Thus, if large pieces are wanted, a small charge is put in vertically, by which the face of the rock is just cracked and the necessary sizes are removed with a pick. If small lumps are required, a large charge is put in in a slanting direction, which blows the rock to pieces.

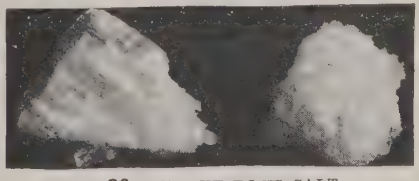
In addition to their mines at Northwich and Winsford, in Cheshire, the Salt Union have mines at Carrickfergus, in Ireland, and they have also white salt works at Northwich, Winsford, Middlewich (Cheshire), Stoke Prior and Droitwich (Worcestershire), Middlesbrough (Durham).



27. ROCK SALT WITH ATTACHED STONE
(One-half scale)



28. ROCK SALT IN NEEDLE-SHAPED CRYSTALS
(One-half scale)



29. OPAQUE ROCK SALT
(One-half scale)

The Uses of Rock Salt. The rock salt is ground to a powder and supplied in bags for agricultural purposes. It is exported in lumps for

refining and conversion into table salts. It is placed unground in the stalls of oxen, who greedily lick it as an adjunct to their food. Brine is used in large quantities in the "Solvay" process for the manufacture of alkali; white salt and rock salt in the "Leblanc" process for the production of soda and salt cake [see Acids and Alkalies], also in copper smelting. As such it forms the basis of several of our most important industries, which are dealt with at full length under different sections. Brine also plays a very important part in the process of refrigeration [see the early part of the chapter]. The following list gives the various other uses to which salt is put:

Scouring
Removing discolorations
Washing greasy bottles
Removing inkstains from carpets and tablecloths
Removing wine-stains
Carpet cleaning
Dissolved in spirit for removing grease-spots
Washing silk handkerchiefs
Mixed with oil for furniture polishes
Cleaning straw matting
Cleaning brooms
Disinfecting
Cleaning slimy sponges
Cleaning stained hands
Cleaning copper (with lemon added)
Making a fire to burn up
On frozen roads
Consolidating roads
Destroying insects in gardens
Destroying vermin in manure heaps
Weed klliing
Doctoring horses, cattle, and sheep
As food for cows to improve milking
With food for cattle to improve appetite and digestion
With poultry food
With all foods deficient in salt
As medicine
In brine baths
As an antidote to poisons, snake and dog bites
Improving the burning of paraffin
Preserving potatoes
Salting down vegetables before cooking
Removing animalculæ from raw vegetables, such as watercress
Salting butter
Bread making (added to flour)
Plugging tobacco pipes
Eating with fruit
Preserving meat
Extracting frost from frozen vegetables
Detecting poisonous mushrooms
Preserving milk
Preserving eggs
Curing hams and bacon
Fish curing and preserving
In liquid form, as a fire extinguisher
Laying dust.
Assisting disintegration and weathering of soil
Absorbing and retaining moisture on the ground, and therefore as a preventive of drought
Assisting the soil to absorb ammonia for crops
Purifying land
Placing on land to cause cattle to crop closer
Increasing clover crops
Checking or preventing potato disease
Sweetening and preserving fodder, and preventing mouldiness in it.

No distinction has been made between *stove* salt, etc., and *rock* salt in the above enumeration, but it may be taken generally that salt from brine is always used in connection with human food and household purposes, and ground rock salt for all others, except where colour and a high degree of purity are of paramount importance.

Natural Vinegars. Genuine vinegar has been defined as the "product of the alcoholic and acetous fermentation of vegetable juice or infusion." That is to say, it is obtained from some vegetable extract which is allowed to ferment, first with the formation of alcohol, which is then converted into acetic acid. Vinegar so prepared will consist of a solution of acetic acid with various vegetable juices and colouring matters. To this class belong the true malt vinegars, prepared from malt or a mixture of malt and barley. The materials are finely ground and *mashed*—that is, extracted repeatedly with small quantities of hot water till all soluble matters are removed. The clear liquors are run off into a vat, where yeast is added, so that fermentation sets in; carbon dioxide gas is given off, and alcohol formed in the liquor. This alcohol has to be further oxidised to form acetic acid, for which purposes some means is adopted to expose it effectually to the oxygen of the air. The action, however, would be slow were it not for the growth of a peculiar fungus, or "vinegar plant" (*Mycoderma aceti*). Either the liquor is allowed to trickle over twigs on which the vinegar plant grows, or the liquor passes through barrels on the sides of which the plant has developed. So prepared, *malt* vinegar has a peculiar and pleasant odour, due to the presence of small quantities of organic substances known as *aldehydes*, *esters*, etc., and it is coloured brown owing to the presence of organic colouring matters formed in the process. Small quantities of vinegar are also prepared from inferior wine, but very little prepared in this manner is met with in this country.

Artificial Vinegars. In contrast to these natural vinegars are the artificial *wood* vinegars, prepared by doctoring a solution of acetic acid obtained by distilling wood and small quantities of caramel, other substances being added to imitate the colour and appearance of *malt* vinegar. A great deal of the vinegar sold is prepared in this way from acetic acid, and at times illegally labelled "malt vinegar." At one time the so-called distilled or *white* vinegar was prepared by distilling the malt vinegar. It is difficult to see what advantages were gained by doing this, as the vinegar so prepared is indistinguishable from diluted acetic acid. A small quantity of sulphuric acid used to be regularly added to the vinegar, with the idea that it helped to preserve it. Such an addition is now illegal, and must be looked for in analysing a sample.

Pepper. Two varieties of pepper are commonly met with—*black* and *white* pepper. Both are obtained from a climbing plant, the *piper nigrum*, often trained like hops or vines to grow on poles. As soon as the berries show signs of turning red they are picked off and dried. *Black pepper* consists of this dried unripe fruit, in the form of rounded berries about one-fifth of an inch in diameter. The outer covering is then blackish-brown and wrinkled, and contains a seed of a yellow-brown or grey colour. This seed, from which the outer coating has been stripped, forms *white pepper*. For this stripping the fruit is soaked in water, in order to soften the husk or outer covering, which is then removed by rubbing. These outer husks possess some of the characteristics of the seed, and are used to a certain extent for flavouring. It will be seen, therefore, that the distinction between black and white pepper lies in the fact that the former consists of the seed contained in its husk or outer covering, while the latter is hulled and contains only the kernel. The peculiar pungency characteristic of pepper is due to the presence of an acrid resinous substance, besides which it contains small quantities of an oily body termed *piperin*, starch, and cellulose or woody fibre. The following table represents the average proportions of certain substances in black and white pepper (Clifford Richardson):

Substances	Black	White
	Per cent.	Per cent.
Water	8 to 11	8 to 11
Ash	2·75 to 5	1 to 2
Volatile oil	·1 to 1·75	·5 to 1·75
Piperin and resin	7 to 8	7 to 8
Starch	32 to 38	40 to 44
Fibre	8 to 11	4·11 to 8
Albuminoids	7 to 12	8 to 10

The manufacture consists in grinding the corns and separating the ground particles by means of

sieves. It is found that most of the active constituents are contained in the finely divided particles, the coarser particles containing mineral impurites and forming an inferior product.

Much ingenuity has been expended by unscrupulous dealers in incorporating with the pepper substances which are not easily discovered by the analyst. Besides the coarser mineral adulterants, such as china clay and starch, substances such as ground olive-stones and *long pepper* may also be added.

Cayenne Pepper. *Cayenne* pepper is obtained from the dried ripe fruit of the *Capsicum fastigiatum* and *Capsicum annum*, which grow in the tropical parts of Africa and America. The pods are orange-red in colour, perhaps ½ in. or so in length, having a shrivelled appearance. Inside are small white, rounded seeds. It owes its peculiar properties to a body known as capsicum, which is colourless, and has a very acrid taste. In addition to this, cayenne pepper consists of fibres and small quantities of fats and resin, but it is noteworthy that it contains no starch. For analysis the chemist must rely mostly on its microscopical appearance.

Mustard. There are two plants which furnish us with the raw material for the manufacture of mustard—namely, the *black* and *white* mustard plants (*Sinapis nigra* and *alba*), yielding respectively black and white mustard seeds. Both plants are found growing wild in most parts of Europe, the white mustard rather more in the south. The seeds differ a great deal in appearance. The white are about one-twelfth of an inch in diameter, and of a palish yellow colour, while the black seeds are considerably smaller, only about one-fifth of the weight of the white ones, and reddish to dark brown in colour. It is only the black mustard seeds which produce the peculiar volatile oil with the penetrating, pungent odour known as *allyl isothiocyanate*, so irritating to the nose and eyes. It is formed when the seeds are macerated with water. It is, however, a curious fact that the addition of white mustard increases the yield of the volatile oil.

To prepare mustard powder, a mixture of the two seeds is crushed between rollers and ground up. The product is then passed through sieves, and an impure mustard flour obtained. This flour is then subjected to a second sifting operation, and the product is ready for the market.

The allyl isothiocyanate exists in mustard in combination as glucoside (*Potassium myronate*), which is split up in the presence of moisture by a ferment, *myrosin*, also found in the seeds. White mustard contains myrosin, and therefore aids the formation of allyl isothiocyanate, although it does not itself contain any of the glucoside. If you wish to prepare some of this volatile oil, you merely require to macerate the black seeds with water, and, after standing for a time, distil, when the oil will pass over with the steam.

In addition to this volatile oil, mustard seeds contain some 35 per cent. of a fixed oil or fat, which is practically odourless and tasteless. There are also present albuminoids, from 25 per cent. to 30 per cent., cellulose, and about 1 per cent. of sulphur. Mustard, however, contains no starch, so that this possible adulterant is easily detected.

Adulterants of Mustard. In addition to starch, other adulterants which have been detected from time to time are turmeric, cayenne pepper, buckwheat, flour, clay, gypsum, and other mineral matters. Some mustard is poor in oil, being prepared from "mustard cake," the residue left after pressing the oil from the ground seeds.

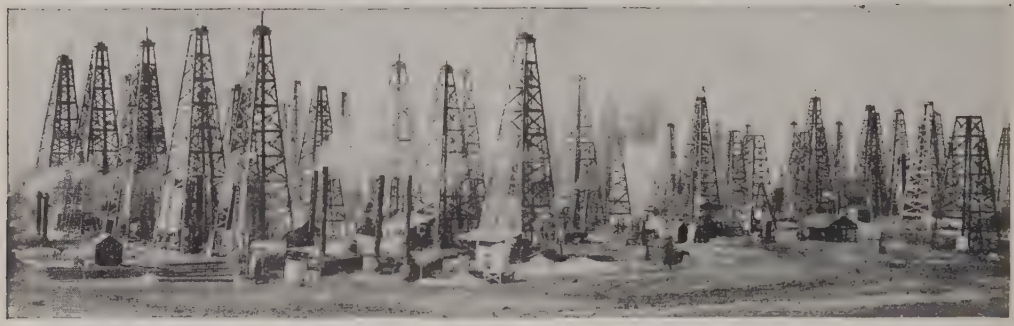
Ginger. Ginger is the dried root, or, more correctly, *rhizome*, of the ginger plant (*Zingiber*), which is a native of India, but has been introduced into a number of other countries, such as Jamaica, Africa, and Japan. The best qualities come from Jamaica. It is prepared by scraping off the outer skin, washing and drying in the sun, and forms rounded, elongated pieces, branching off from one another. The usual colour is a pale buff, but sometimes the outer skin is not removed. "Coated ginger," or the scraped root, is whitewashed with chalk or chloride of lime to preserve it from the attacks of insects. The peculiar odour of ginger is due to a volatile oil, amounting to about ¼ per cent. of the weight of the root. The pungent taste is due to another constituent. In general, the composition of ginger varies a good deal; it contains resins, starch, fibre, and mineral matters.

Fraudulent practice in dealing with ginger is mostly confined to the sale of the "exhausted" product—that is to say, ginger which has been ground up and the essential constituents removed by digesting with weak spirit for making essences, etc. This form of adulteration is difficult to detect, as the appearance of the ginger is not altered.

Spices. Among the spices, *caraway seeds* are the dried fruit of the *Carum carui*, and contain about 5 per cent. of a volatile oil. *Cloves* are the dried calyx and flower buds of the *Eugenia caryophyllata*, a sort of myrtle which grows in Zanzibar and the West Indies. As in other spices, they owe their peculiar flavouring properties to a volatile oil, of which they contain up to 16 per cent. Allspice or *pimento* is the small dried berry of another variety of myrtle, the *Pimenta officinalis*. It contains about 4 per cent. of an oil similar to oil of cloves. Being cheaper, it is sometimes used to adulterate the latter. *Mace* is the outer coat or *arillus* of the *nutmeg*, the fruit of the nutmeg tree, *Myristica fragrans*. Nutmeg contains 6 per cent. of a pungent volatile oil, and mace about 4½ per cent. of a volatile oil. *Cardamoms* are the dried ripe seeds of several plants, and include the so-called "grains of Paradise." They contain the usual volatile oil and resin. *Cinnamon* is the bark of several allied trees, the best of which comes from Ceylon. The bark is stripped off in spring and autumn. It contains up to 1 per cent. of an essential oil, to which it owes its flavouring properties. It is sometimes adulterated with *cassia*, the bark of trees of the same genus, but of inferior value. Cassia is easily distinguished from true cinnamon, the latter consisting of thin curled pieces from which the outer and inner coats of the bark have been removed, while cassia forms thick pieces consisting of the entire bark.

Adulteration of Spices. Spices are very frequently adulterated, sometimes by the substitution of an inferior article, such as pimento for cloves or cassia for cinnamon, and also by the addition of various other waste materials, such as sand, gypsum, walnut and coconut shells ground up, ground olive-stones, mustard husks, and pepper refuse. These adulterants are readily mixed in with the ground spice; it is therefore much better to buy the whole spice and grind it as required for use. But even then certain adulterations may be effected.

FIELDS OF ACTIVITY IN THE OIL INDUSTRY



A FOREST OF DERRICKS ON AN OILFIELD

A CALIFORNIAN OILFIELD WHICH EXTENDS BENEATH THE PACIFIC OCEAN

A LONDON OIL-TRAIN AT A THAMES-SIDE FILLING STATION
The bottom picture is by courtesy of the Anglo-American Oil Company

Physical and Chemical Properties of Crude Petroleum.
Systems of Drilling Wells. Transport and Storage.

OIL PRODUCTION AND TRANSPORT

Physical Properties of Crude Petroleum. The unusual character of petroleum was the subject of much speculative comment by early writers on philosophical subjects. Thus, Francis Bacon, in 1627, described "the original concretion of bitumen" as a mixture of fiery and watery substance, and stated that "flame attracts the bitumen of Babylon afar off." Numerous references to the inflammable nature of petroleum were also made by the ancient historians. In his Life of Alexander, Plutarch describes how, in the district of Ecbatana (Kerkuk), Alexander was particularly struck with "a gulf of fire which streamed continuously, as from an inexhaustible source. He admired also a flood of naphtha not far from the gulf, which flowed in such abundance that it formed a lake. The naphtha in many respects resembles the bitumen, but it is much more inflammable. Before any fire reaches it, it catches light from a flame at some distance, and often kindles all the intermediate air. The barbarians, in order to show the king its force and the subtilty of its nature, scattered some drops of it in the street which led to his lodgings, and, standing at one end, they applied their torches to some of the first drops, for it was night. The flame communicated itself quicker than thought, and the street was instantaneously all on fire. . . ."

Hatchett, writing in 1798, divided bituminous substances into naphtha, petroleum, mineral tar, mineral pitch, asphaltum, jet, pit coal, bituminous wood, turf, and peat, and stated that when *naphtha*, the light, thin, often colourless oil, lost its lighter parts by exposure to the air, it yielded *petroleum*, which on further exposure gave *mountain* or *mineral tar*. Continued exposure, he added, produced *mountain* or *mineral pitch*, which in cold weather became brittle, but was soft and somewhat tenacious when warm, and by further induration *asphaltum* was produced.

Crude petroleum varies greatly in appearance, some descriptions being of pale colour and highly mobile, while others are viscid and almost black. The prevailing *colour* of the more fluid kinds of crude petroleum is chestnut-brown when viewed so that the light passes through the oil, but when the light is reflected from the surface of the oil the colour appears to be olive-green. An important indication of the character of a crude petroleum is afforded by its *specific gravity*, which is the ratio of the weight of a given bulk to that of an equal volume of water at 60° F.

Specific Gravity. The specific gravity of crude petroleum ranges from a little under 0·775 to a little over 1·0; therefore the lightest crude petroleum is about three-fourths the weight of water, and the heaviest about the same weight as water; but as it is exceptional to find crude petroleum approximating in specific gravity to the higher limit, the general experience is that it freely floats on water. When the area of a sheet of water on to which petroleum is flowing is sufficiently large in relation to the quantity of oil, the petroleum immediately spreads out into an exceedingly thin film which, on account of its tenuity, is iridescent, or, in other words, exhibits the colours of the rainbow, just as a soap-bubble does. This characteristic film has often led to the discovery of a valuable source of petroleum. Most descriptions of crude petroleum employed as a source of the usual commercial products have specific gravities between 0·8 and 0·9, but even within these narrower limits the specific gravity is a valuable guide to the nature of the oil. As a rule, the lighter the oil, the larger the proportion of kerosene or burning oil obtainable from it; and if the specific gravity exceeds 0·9, the petroleum will usually be found best suited for use as a fuel, or, in some instances, for the manufacture of lubricating oils. The *flash-point* of the oil, or the temperature at which it gives off inflammable vapour when tested in a prescribed manner (to be hereafter described), also affords an indication of the character of the oil. Most crude oils freely evolve inflammable vapour at ordinary temperatures; but if the oil requires to be heated considerably in order to cause the rapid evolution of vapour, it may be safely assumed that it is of little value as a source of kerosene; still less of the more volatile petroleum spirit used in motor vehicles. The *odour* of the oil is also a feature to be noted, for petroleum containing the objectionable impurity sulphur usually has an offensive odour, the normal odour of petroleum of high quality being not unpleasant. The temperature at which crude petroleum, which is quite fluid when warm, becomes solid on cooling affords an indication of the proportion of solid constituents present, which can be separated in the process of refining as paraffin wax, for candle-making. Thus, the crude petroleum of Burma, which yields a large percentage of this valuable commercial product, is solid at common temperatures, but becomes quite fluid on being warmed.

Chemical Properties of Crude Petroleum. To Hatchett, who has been already referred to, belongs the credit of having been among the first to form a clear conception of the chemical composition of petroleum, for he stated quite correctly, as early as 1798, that "the elementary principles of bitumen are carbon, hydrogen, sometimes azote (nitrogen), and probably some oxygen." The *carbon* appears to range between 79·5 and 88·7 per cent., and the *hydrogen* between 9·6 and 14·8 per cent. The proportion of *nitrogen* rarely approaches 1 per cent., and is usually very much lower than this. *Oxygen* also occurs only in small quantities, usually in the form of an acid. Some oils contain as much as 2 or 3 per cent. of sulphur, an impurity which frequently necessitates the adoption of a special refining process for its elimination. The carbon and hydrogen, of which all descriptions of crude petroleum are principally composed, occur in the form of liquid or solid chemical compounds termed *hydrocarbons*. Of these compounds, a large number have been isolated for examination, and it has been found that they constitute well-defined groups. Thus, the crude petroleum of the United States consists chiefly of a regular series of the compounds known as *paraffins*, each containing twice as many atoms of hydrogen as of carbon, and

two atoms of hydrogen in addition, while that of Russia consists principally of the compounds termed *naphthenes*, in which there are twice as many atoms of hydrogen as of carbon. Thus, among the hydrocarbons separated from American petroleum we have at one end of the series C_5H_{12}, C_6H_{14}, C_7H_{16}, etc., and at the other end $C_{25}H_{52}$, $C_{27}H_{56}$, $C_{30}H_{62}$; while the hydrocarbons separated from Russian petroleum include C_6H_{12}, C_7H_{14}, C_8H_{16}, etc., up to $C_{15}H_{30}$. These hydrocarbons exhibit regular progression in the *boiling-point*, those with least carbon being the most readily volatilised, and those with most carbon having the highest boiling-points. This character enables the petroleum refiner to classify the hydrocarbons present by the process known as fractional distillation, so as to obtain the desired commercial products.

The Production of Crude Petroleum. The operation of obtaining petroleum by the drilling of wells, which is technically termed "production," has been systematically conducted only during the past half-century; but the collection of the oil by the primitive process of skimming it from the surface of stagnant water, or bailing it from shallow excavations, was practised for ages previously, the oil being used as a lubricant for cart-axles, as a preservative of woodwork, especially of boats, and to a smaller extent as a medicinal agent. Before the drilling of wells was begun, there was an intermediate stage, during which petroleum wells were dug in the same fashion as a water-well, and were commonly lined with wood. In some countries, and notably in Burma and Rumania, the sinking of such wells was carried out with great ability and success, remarkable depths being reached, notwithstanding the difficulty and danger of the work, arising from the presence of suffocating vapour.

The Earliest Uses of Petroleum. The earliest detailed description of the collection of petroleum is that given by Herodotus, who describes operations which were carried on at the pits of Kir ab-ur Susiana (Kirab, 57 miles north-west of Shuster, in Persia).

Marco Polo, writing at the end of the thirteenth century, says of the petroleum of Baku, on the Caspian Sea: "On the confines towards Georgine there is a fountain from which oil springs in great abundance, inasmuch as a hundred shiploads might be taken from it at one time. This oil is not good to use with food, but is good to burn, and is also used to anoint camels that have the mange. People come from vast distances to fetch it, for in all the countries round there is no other oil."

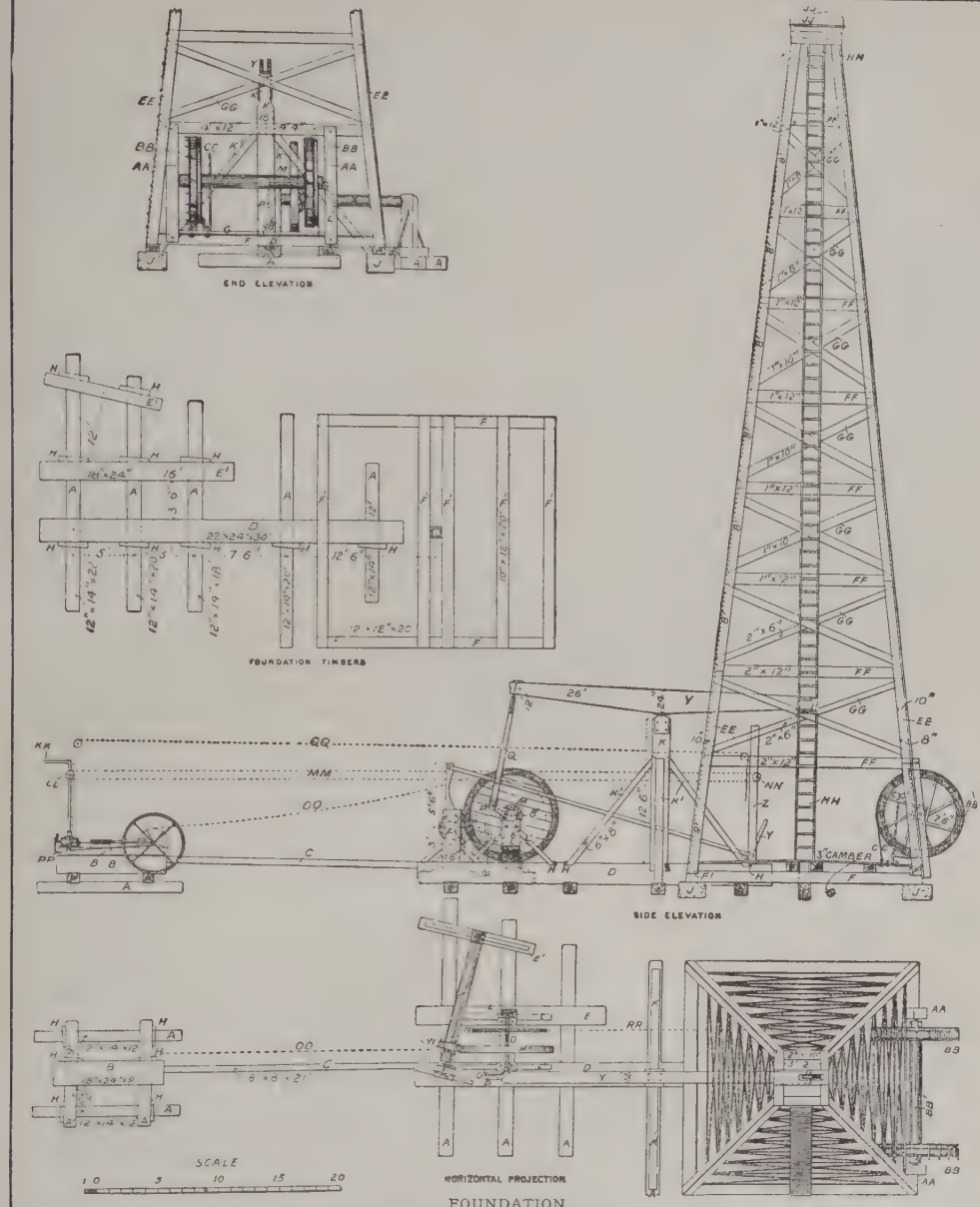
Petroleum in England. There are many historical references to the occurrence of petroleum in England. An interesting case of the sudden influx of petroleum into a water-well at Ashwick Court, near Shepton Mallet, in Somersetshire, in the year 1892, was investigated at the time by the late Mr. Topley and the author. The well in question, which was the sole source of the water supply of the house, yielded, for some hours after the occurrence of an earthquake shock, a considerable quantity—stated to amount to several barrels—of petroleum. Petroleum has also recently been found in drilling for coal at Kelham, near Newark. On the other hand, several reported discoveries of petroleum have undoubtedly been explicable on the assumption that the oil had leaked from neighbouring petroleum stores. In the United Kingdom small quantities of petroleum have been obtained in North Staffordshire and Yorkshire, and during 1905 there was a production of forty-six tons in Dumbartonshire.

Modern Drilling Plant. The modern appliances most largely used consist of a percussion drill, driven by steam power, by means of which the rock is broken up and mixed with water to the consistency of mud, the detritus being removed from the borehole from time to time by the use of a long iron cylinder having a valve at the lower end. To a comparatively small extent a system of percussion drilling is also employed in which a stream of water under high pressure is driven through hollow drilling-rods, and issues from orifices in the cutting instrument or bit, the detritus being thus continuously washed out of the borehole. A rotary drill, with a circular cutting edge, has been employed for many years in the oilfields of Texas and Louisiana.

Cable System. There are several forms of percussion drill, chiefly differing in details, but there are only two to which it is necessary to direct special attention, as it is with these that the greater part of the work of drilling for petroleum has been, and is being, done. These are the American or cable system, in which the drilling tools are suspended by a manila cable, and the Canadian or rod system, with the modification used in Russia, in which the tools are attached to a string of jointed rods of wood or iron. The general appliances are substantially similar in these two systems, and it will therefore suffice to give a detailed description of the American or cable tools and machinery.

Oil-well Rig. The illustration shows a simple form of the standard rig employed in American oilfields. The derrick is a strong timber structure, usually at least 70 ft. in height, and 20 ft. square at the base, resting on wooden sills, and fixed by means of keys, so that it may readily be taken down and set up on a new site. To the band-wheel, which is fixed on the foundations a short distance from the derrick, motion is communicated by means of a belt from a horizontal steam engine of 30 to 35 horse-power, fitted with reversing gear. While drilling is in progress, this band-wheel imparts motion to the walking-beam, one end of which is immediately above it, through the medium of the crank and the wooden connecting-rod, or *pitman*, the length of stroke being adjustable, as shown in the illustration. At the opposite side of the derrick is a strong windlass, termed the *bull-wheel*, which is driven from the band-wheel, when required to be used, by means of an endless rope. The bull-wheel is provided with a powerful brake. A smaller windlass, called the *sand-pump reel*, is placed so that it can be driven off the band-wheel by a friction-pulley, actuated by a lever pivoted to the derrick floor. The throttle-valve of the engine is opened or closed by means of an endless cord passing into the derrick, the motive power being thus under the control of the driller. The drilling tools are attached to an untarred manila cable, 2 in. in diameter, which is coiled round the bull-wheel shaft and passes thence over a pulley at the top of the derrick, but when drilling is in progress they are suspended from the end of the walking-beam over the mouth of the well, and thus have the necessary vertical motion imparted to them.

The string of drilling tools consists of two parts separated by the jars, the lower one giving the downward blow, and the upper imparting an upward stroke, which serves to loosen the bit if it has become jammed in the rock. The lower portion consists of the bit, the auger-stem, and the lower half of the jars, while the upper portion



FOUNDATION

a Mud-sills
a′ Cross sills for engine blocks
b Engine-block
b′ Engine
c Engine-block brace
d Main sill
e Sub-sill for jack post of band-wheel
e′ Sub-sill for jack post of sand pump reel
f Derrick sills
f′ Derrick-floor sills
g Derrick floor
h Keys or wedges
i Conductor
j Corner stones or blocks

SUPERSTRUCTURE

k Samson-post
k′ ,, ,, braces
k″ ,, ,, irons
l Band-wheel jack posts
l′ Braces of ditto
m Band-wheel
n ,, ,, bull-rope pulley
o Band-wheel shaft
o′ Band-wheel arm
p ,, ,, wrist-pin
q Pitman
r Knuckle-post for sand-pump reel
s Jack post for ditto
t Upright lever
u Connecting bar
v Hand-lever in derrick
w Friction pulley of sand-pump reel
x Shaft of sand-pump reel
y Walking beam
z Headache post
aa Bull-wheel posts
bb Bull-wheels
bb′ Bull-wheel shaft
cc Bull-wheel brake-band
cc′ Bull-wheel brake-band
ee Derrick stiles [lever
ff ,, girths
gg ,, braces
hh ,, ladder
ii ,, sand-pump pulley
jj ,, crown pulley
jj′ ,, ,, ,, block

GEARING

k Steam-pipe connecting with boiler
ll Throttle-valve
mm "Telegraph" cord which operates throttle-valve
nn Pulley in derrick for telegraph cord
oo Driving-belt
pp Reversing-link of engine
qq Cord operating ditto from derrick
rr Place of the bull-wheel rope

PETROLEUM RIG USED IN AMERICAN OILFIELDS

consists of the upper half of the jars, the sinker-bar, and the rope-socket with temper-screw. The bit is a steel-faced, chisel-shaped implement, about 4 in. in thickness, and of a width corresponding with the desired diameter of the borehole. The auger-stem is a solid rod, about 4 in. in thickness, and about 32 ft. in length. The jars may be described as resembling two long, flattened links of a chain. The sinker-bar is another solid rod about 12 ft. in length. The rope-socket is an arrangement for grasping the cable, and the temper-screw is a device for gradually lowering the string of tools as the drilling progresses. The various component parts of the string of tools are connected by male and female screws, the collars being squared for the application of wrenches.

Drilling the Well. In beginning a well, an ordinary shaft about 8 ft. or 10 ft. square is dug to a depth of 10 ft. or 15 ft., and a strong iron pipe furnished with a sharp steel shoe is driven down to a depth of 200 ft. or 300 ft., or until hard rock is encountered. The drilling tools suspended to the walking-beam are then set to work, and the rock is broken up by the successive blows of the bit. From time to time the walking-beam is disconnected, the bull-wheel set in motion, the tools drawn up into the derrick, and the detritus removed from the borehole by means of the sand-pump. This is a long iron cylinder, with a valve at the lower end, opening inwards. It is suspended from a cord passing over a small pulley at the top of the derrick to the sand-pump reel. On being lowered to the bottom of the well, the valve opens, and the cylinder fills with the detritus, which has been brought to the consistency of mud by means of water poured into the well as the drilling proceeds. On being raised by bringing the friction-pulley into contact with the band-wheel, the valve closes, and the contents of the cylinder are removed. While the tools are in the derrick opportunity is taken to sharpen the bit if it has become blunted.

Casing the Well. In some formations the drilling cannot be carried far without lining the well with iron casing to support the walls; and when a water-bearing stratum is perforated it is the practice to exclude the water by making a seating for this casing on a lower-lying impervious stratum, and continuing the drilling with a smaller bit and with the use of casing of less diameter, each string of casing extending to the surface. Apart from the necessity which may thus arise for reducing the diameter, it is usually found that when a considerable depth has been reached the casing becomes so firmly held by the walls of the well that it cannot be forced down any farther, and a smaller string has then to be inserted, with the result that wells of a depth of, say, 2000 ft., or from 2000 ft. to 3000 ft., may contain, when completed, many strings of casing.

Canadian System. The original Canadian or *rod* system differs from the system already described in the following particulars:

1. The substitution of wooden boring-rods for the cable. [See page 4386.]
2. The use of an auger in place of the spudding-bit in beginning the well.
3. The adoption of a somewhat different arrangement for transmitting motion.
4. The employment of a lighter set of drilling tools.

Russian System. In Russia (Baku oil-fields) the wells are of large diameter (often as much as 36 in., or even more, at the top) in order to reduce the risk of choking through masses of rock being driven into the bottom of the borehole by gas pressure, and to admit of the use of bailers of large size in raising the oil, the presence of sand preventing the employment of ordinary pumps. The drilling of wells of this large diameter is a comparatively slow and costly operation, necessitating the adoption of heavy tools and strong appliances generally. The system of drilling may be described as a modification of the Canadian system, in which iron rods are substituted for the wooden rods. Owing to their large diameter, the Russian wells are chiefly lined with riveted iron-plate casing instead of with the screwed artesian casing used in America.

Galician System. When the Canadian system was introduced into Galicia, it was found that considerable increase in the size and weight of the tools was rendered necessary by the greater hardness of some of the strata and the depth of the wells, but in principle the system remained substantially the same until recently. Now, however, it has become customary to employ a combination of the rod or pole system with the cable system, owing chiefly to further increase in the depth of the wells, which renders the time lost in disconnecting and reconnecting the screw-jointed poles a serious drawback, but in making this change a wire rope has been adopted in place of the manila cable used in America. In addition to the ordinary drilling tools, an expanding reamer is largely used in Galicia. This device is provided with two pivoted wings or dogs, forced outwards by powerful springs, and by means of it the size of the borehole can be increased at the bottom so as to admit of the casing descending quite freely.

Fishing Tools. In addition to the drilling tools employed in the various percussion drilling systems, a large number of "fishing" tools, many of which are of ingenious construction, are needed to deal with various mishaps which occur. A fracture of the drilling tools or cable or rods is not infrequent, or some portion of the string of tools may become detached, and in the absence of suitable appliances the well might have to be abandoned. By means of the fishing tools the broken end of the cable or rod can be grasped, or a hole drilled in a fractured tool lying at the bottom of the borehole, and tapped to receive a screw so as to admit of its being raised

Rotary System. The rotary system of drilling, already alluded to as being in use on the costal plain of Texas and elsewhere, is based upon that of Fauvelle, which was invented in 1842. It is admittedly one of the most rapid and economical systems which can be adopted in formations to which it is suited, but where very hard rock is encountered it is almost useless. It consists essentially in the employment of hollow drilling-rods or casing terminating in a drilling-bit or annular cutter, through which a continuous stream of water is pumped under a pressure ranging from 40 lb. to 100 lb. per square inch. The derrick is similar to that which has been described, but it is provided with a revolving table and gearing for rotating it by steam power, by means of which the rotation of the casing and bit is effected. The drilling tools are supported by a cable which passes from a swivel attached to them through a block and fall, and over a pulley at the top of the derrick to the hoisting drum. A flexible hose-connection is made from the swivel to the water-pumps, of which there are two, in order to ensure a continuous supply of water. The bits commonly employed

are the fish-tail, the core-barrel, and the adamantine or shot drill. The fish-tail bit is used for drilling in soft strata, such as sand and clay; the core-barrel bit in harder material, such as very compact clay, indurated sand, etc. In hard rock these two bits are ineffective, the progress made with them being very slow—in some cases only a few inches per day. Under these conditions the adamantine or shot drill is used, the abrasion of the rock being effected by steel shot, which are caused to revolve by the action of the bit. The detritus is carried continuously to the surface by the current of water passing downwards through the hollow rods or casing, and ascending in the annular space outside, and there is thus no need for the periodical clearing out of the borehole by means of a sand-pump, as in the ordinary percussion drilling system. If a porous stratum is met with, the water is liable to percolate into the rock; and to prevent this the water which is being pumped in is mixed with fine clay or mud, the porous bed being thus cemented up. The rotary system of drilling has been greatly improved within the past few years, and is now largely employed in the principal oilfields, either alone or, where hard strata are met with, in combination with the percussion system.

A TYPICAL GUSHER, WHICH YIELDS SOME THREE HUNDRED THOUSAND GALLONS OF OIL A DAY

Depth and Cost of Wells. In Pennsylvania the wells range in depth from 300 ft. to 3700 ft. Those of average depth cost about $3000, but the deeper ones may cost as much as

$7000. In Indiana the depth of the wells ranges from 900 ft. to 1650 ft., and the cost from $1200 to $1500. The average cost of the Texas wells is about $2000. The deepest well in the United States is said to be one drilled for water in Connecticut, which reached a depth of 6004 ft., with a diameter of 6 in. The second deepest was one in Pennsylvania, with a depth of 5575 ft. Many of the wells in the Boryslaw-Tustanowice district of Galicia are of a depth exceeding 5000 ft., and one has yielded oil from strata which have been reached at 5873 ft., or nearly a mile and a furlong.

Torpedoing Wells. In some of the oil-fields of the United States it is customary to explode a charge of nitro-glycerine at the bottom of the well in order to fracture the adjacent rock and thus facilitate the inflow of oil, as much as 100 or even sometimes 200 quarts of the explosive being employed in the deeper wells. The nitro-glycerine is carefully lowered into the well in a series of tin canisters, from 3½ in. to 5 in. in diameter and 10 ft. in length, the charge being exploded by a "go-devil squib" holding about a quart of nitro-glycerine and furnished with a percussion or time fuse.

Flowing Wells. In some localities a large proportion of the wells flow on completion, and not infrequently the stream of oil gushes from the borehole with almost uncontrollable violence, creating a spouter or fountain which may rise in the air to a height of 200 ft. or 300 ft. This is notably the case in the Baku oilfields, where the pressure exerted by the oil is said to have occasionally amounted to as much as 300 lb. per square inch. If the well spouts to a great height, the oil-spray is liable to be carried by the wind to a considerable distance, and ignition may occur at some boiler-fire, with the result of communicating flame to the well. A block of cast iron, about 4 ft. square and 6 in. to 8 in. in thickness is therefore placed in the derrick at a height of about 25 ft. above the mouth of the well, and the oil playing against this is confined to the immediate neighbourhood of the well. As soon as possible the oil is led into an excavation in the ground near the derrick; but although such a reservoir holds from 4000 tons to 6000 tons, it is quickly filled with oil and sand if the fountain is a strong one, and the derrick may even be buried in a sandhill in a short time. In such cases great loss of oil is unavoidable. The life of a fountain is very uncertain. The violent outbursts often lasts only for a few days or weeks, but the fountain may continue to play for more than a year. When the Baku wells do not flow, the oil is raised by means of bailers, which are long cylinders, similar to the sand-pump already described, with a valve at the bottom, for ordinary pumps cannot be used, owing to the large quantity of sand contained in the oil. Compressed air is also to some extent used to force the oil to the surface. From the earthen reservoirs the oil is pumped into cylindrical steel storage tanks after the sand has settled out of it, and is thence conveyed by pipe-lines to the refineries.

Yield of Wells in the United States. Although in some of the oilfields of the United States flowing wells yielding very largely are obtained, the average initial daily production of the whole of the productive oil-wells drilled in 1903 in the Appalachian oilfield (embracing the producing region in New York, Pennsylvania, West Virginia, Kentucky, Tennessee, and the south-eastern portion of Ohio) was 11·8 barrels per well. The term "initial daily production" signifies the quantity that any new well will produce during the first day after it has been completed.

Transport of Crude Petroleum. In the days of King Theebaw the produce of the wells in Upper Burma was carried in earthenware vessels. For many years subsequently the oil was brought down the river in bulk-barges, termed flats, by the Irrawadi Flotilla Company, but it is now transported from the oilfields to Rangoon by means of a pipe-line constructed by the Burma Oil Company. In Russia, until 1875, the crude oil was carried in barrels on Persian carts, known as "arbas," with huge wheels, 8½ ft. to 9 ft. in diameter, one barrel being placed in the body of the vehicle, and a second slung beneath the axle. In the United States the oil was at first transported in oak barrels, but after a short time bulk-barges, and an early form of tank railway-car with two wooden tub-like tanks, were empolyed. In 1871 railway cars with the present form of horizontal cylindrical iron or steel tanks were introduced.

Pipe Lines. The first successful pipe-line in the United States was laid in 1865, but it was not until 1875 that the construction of the great trunk lines was rendered necessary by the transference of the refining industry from the neighbourhood of the wells to the Atlantic seaboard and the shores of the Great Lakes. In 1892 the aggregate length of the trunk lines (chiefly 6 in. and 8 in. in diameter) was nearly 3000 miles, several of the individual lines being from 200 to 400 miles in length. In addition, there was a network of feeder-lines of smaller size, bringing the total length of piping up to about 25,000 miles. Since that date the number of lines and their capacity have been very largely increased. The trunk pipe-lines are made up in 18-ft. lengths of specially made lap-welded iron or steel pipe, tested to 2000 lb. per square inch, connected by long-sleeved screwed couplings, and are usually laid two or three feet below the surface of the ground, with bends at intervals to provide for contraction and expansion. The oil is forced through the lines by specially constructed pumps, which keep the column of oil in constant motion at a uniform rate of about three miles an hour; and in order to keep the lines clear of sediment a rotary scraper with radial arms, known as a *go-devil*, is from time to time forced through with the oil. The lines are worked in sections, with a pumping station for each portion.

Storage of Crude Petroleum. At convenient centres storage installations are erected. The tanks employed for this purpose in the United States are vertical cylindrical iron or steel tanks 90 ft. in diameter and 30 ft. in height, holding about 35,000 barrels. The tanks have slightly conical roofs covered with sheet iron.

Natural Gas. In the account already given of the geological and geographical distribution of petroleum a brief allusion was made to the gas so largely obtained in some portions of the Appalachian oilfields. The gas-wells are similar to the oil-wells; indeed, a well drilled for oil occasionally produces gas, and gas-wells after a time yield oil. The pressure under which the gas is met with may be as much as 800 to 900 lb. per square inch, and some wells have yielded about 30,000,000 cubic ft. daily. The gas is conveyed from the wells to distributing stations in pipe-lines like those used for oil.

Ozokerite. This is one of the solid forms of petroleum, and is mined in Galicia by means of shafts and galleries, similarly to coal, but exceptionally heavy timbering and efficient ventilation are needed. BOVERTON REDWOOD

Logarithms. Formulæ Connecting the Sides and Angles of a Triangle. Four Cases of Solution of Triangles.

SIDES & ANGLES OF A TRIANGLE

LOGARITHMS—continued

31. The decimal part of a logarithm is called the *mantissa*: the integral part is called the *characteristic*.

The logarithms of two numbers which have the same digits in the same order (i.e., they differ only in the position of the decimal point) have the same mantissa.

For example, let the numbers be 147·2 and ·01472. Then

$$147\cdot2 = \cdot01472 \times 10^4.$$
$$\therefore \log 147\cdot2 = \log \cdot01472 + 4 \log 10$$
$$= \log \cdot01472 + 4.$$

Hence, by keeping the mantissa always positive, the logarithms of numbers expressed by the same digits will only differ in the characteristic. Now, the characteristic of the logarithm of a given number can always be obtained by inspection. From Article **30** it is evident that

(i.) The characteristic of the logarithm of a number greater than 1 is *one less* than the number of *integral* figures in the number. Thus, characteristic of log 549·287 is 2, since there are *three* figures in the integral part, 549, of the number.

(ii.) The characteristic of the logarithm of a number less than 1 is negative, and is *one more* than the number of noughts between the decimal point and the first significant figure. The characteristic of log ·000582 is -4.

In order to denote that only the characteristic is negative, and the mantissa positive, the negative sign is written *over* the characteristic, and not *before* it. Thus, if the logarithm of a number is $-2+$ ·8257143, it is written $\bar{2}$·8257143.

Since the characteristic is found by inspection, the mantissa only is printed in the book of logarithms. For example, opposite the number 59082 we find 7714552. This means that 7714552 is the decimal part of the logarithm of any number which consists of the digits 59082 in that order. Thus, log 5908·2 = 3·7714552; or log ·059082 = $\bar{2}$·7714552.

32. Books of logarithms vary in detail, but all of them contain instructions for using their contents. In *Chambers' Mathematical Tables*, mentioned on page 5663, the use of the tables is explained by many worked examples, which the student will find no difficulty in understanding. The only thing we need refer to here is the *Rule of Proportional Differences*. The tables give the logarithms of numbers from 1 to 100,000, *i.e.*, number of five figures. The above rule enables us to find, by means of the tables, the logarithms of numbers having six or seven figures.

The rule is that *when the differences between three numbers are small compared with the numbers these differences are proportional to the corresponding differences between the logarithms of the numbers.*

Example. Find log 33651·4, having given that log 33651 = 4·5269980 and log 33652 = 4·5270109.

Let log 33651·4 = 4·5269980 + d.

Then, we have three numbers: 33651, 33651·4, 33652. The differences between the first and second and between the first and third are ·4 and 1. Again, we have three logarithms corresponding to the numbers, viz.:

4·5269980, 4·5269980 + d, 4·5270109.

The corresponding differences are d and ·0000129, and they are in proportion, so that

$$\frac{d}{\cdot0000129} = \frac{\cdot4}{1},$$

whence d = ·0000052 (to seven places).

$$\therefore \log 33651\cdot4 = 4\cdot5269980 + \cdot0000052$$
$$= 4\cdot5270032.$$

33. The logarithms of the ratios of all angles from 0° to 90° have also been tabulated. Sines and cosines are less than 1, and so also are tangents of angles between 0° and 45°. The logarithms of these ratios will therefore have *negative* characteristics.

To avoid printing these negatives, the number 10 is added to each logarithm. The result is called the *tabular* logarithm of the sine, cosine, etc., and is indicated by the letter L. Thus, in the tables we find L tan 35° 4′ = 9·8463018, so that log tan 35° 4′ = 9·8463018 − 10 = $\bar{1}$·8463018.

The rule of proportional differences is applied in the same way as in the case of numbers, so that from the logarithms of tan 35° 14′ and tan 35° 15′ we can find log tan 35° 14′ 25″, say.

Sides and Angles of a Triangle

34. In a triangle ABC, the letters A, B, C are used to denote the number of degrees in the angles at the points A, B, C respectively; so that "sin A" means "sine of the angle at A." The letters a, b, c, denote the lengths of the sides BC, CA, AB, *i.e.*, the sides opposite respectively to the points A, B, C.

35. *To prove that* $\cos A = \dfrac{b^2 + c^2 - a^2}{2bc}$.

Since a Δ has at least two acute angles, one of the angles B, C, must be acute. Let B be acute. Draw CD $\perp$ to BA or BA produced. In the three cases, where A is acute, obtuse, or a right angle, we have

(1) $BC^2 = CA^2 + AB^2 - 2\,BA\,.\,DA$ (*Prop.* 69);
or, $a^2 = b^2 + c^2 - 2c\,.\,DA$.

But $\frac{DA}{AC} = \cos A$, so that $DA = b \cos A$.

$\therefore a^2 = b^2 + c^2 - 2bc \cos A$.

(2) $BC^2 = CA^2 + AB^2 + 2BA\,.\,AD$ (*Prop.* 70);
or, $a^2 = b^2 + c^2 + 2bc \cos DAC$.

But $\cos DAC = \cos(180° - A) = -\cos A$.

$\therefore a^2 = b^2 + c^2 - 2bc \cos A$.

(3) $BC^2 = CA^2 + AB^2$.

$\therefore a^2 = b^2 + c^2 - 2bc \cos A$,
since $\cos A = \cos 90° = 0$.

Hence, in all three cases we have

$$\cos A = \frac{b^2 + c^2 - a^2}{2bc}.$$

Similarly,

$$\cos B = \frac{c^2 + a^2 - b^2}{2ca}, \quad \cos C = \frac{a^2 + b^2 - c^2}{2ab}.$$

36. Let $a + b + c = 2s$.
Then $b + c - a = b + c + a - 2a = 2s - 2a = 2(s - a)$.
Similarly, $c + a - b = 2(s - b)$,
and $a + b - c = 2(s - c)$.

37. *To prove that*

$$\sin \frac{A}{2} = \sqrt{\frac{(s-b)(s-c)}{bc}},$$

and

$$\cos \frac{A}{2} = \sqrt{\frac{s(s-a)}{bc}}.$$

We have $2 \sin^2 \frac{A}{2} = 1 - \cos A$ [Art. 26]

$$= 1 - \frac{b^2 + c^2 - a^2}{2bc} = \frac{2bc - b^2 - c^2 + a^2}{2bc}$$

$$= \frac{a^2 - (b^2 + c^2 - 2bc)}{2bc} = \frac{a^2 - (b-c)^2}{2bc}$$

$$= \frac{(a + b - c)(a - b + c)}{2bc} = \frac{2(s-c)\,.\,2(s-b)}{2bc}.$$

$\therefore \sin \frac{A}{2} = \sqrt{\frac{(s-b)(s-c)}{bc}}$.

Also,

$$2 \cos^2 \frac{A}{2} = 1 + \cos A = 1 + \frac{b^2 + c^2 - a^2}{2bc}$$

$$= \frac{2bc + b^2 + c^2 - a^2}{2bc} = \frac{(b+c)^2 - a^2}{2bc}$$

$$= \frac{(b + c + a)(b + c - a)}{2bc} = \frac{2s\,.\,2(s-a)}{2bc}.$$

$$\therefore \cos \frac{A}{2} = \sqrt{\frac{s(s-a)}{bc}}.$$

Similarly,

$$\sin \frac{B}{2} = \sqrt{\frac{(s-c)(s-a)}{ca}}, \quad \cos \frac{B}{2} = \sqrt{\frac{s(s-b)}{ca}},$$

$$\sin \frac{C}{2} = \sqrt{\frac{(s-a)(s-b)}{ab}}, \quad \cos \frac{C}{2} = \sqrt{\frac{s(s-c)}{ab}}.$$

38. From the last article we have

$$\tan \frac{A}{2} = \frac{\sin \frac{A}{2}}{\cos \frac{A}{2}} = \frac{\sqrt{(s-b)(s-c)}}{\sqrt{s(s-a)}}.$$

Similarly for $\tan \frac{B}{2}$ and $\tan \frac{C}{2}$.

39. Since $\sin A = 2 \sin \frac{A}{2}\,.\,\cos \frac{A}{2}$ [Art. 26].

$$\therefore \sin A = 2 \cdot \sqrt{\frac{(s-b)(s-c)}{bc}} \cdot \sqrt{\frac{s(s-a)}{bc}}$$

$$= \frac{2}{bc} \cdot \sqrt{s(s-a)(s-b)(s-c)}.$$

The expression $\sqrt{s(s-a)(s-b)(s-c)}$ is usually denoted by S. Hence, $\frac{\sin A}{a} = \frac{2S}{abc}$. In the same way we get $\frac{\sin B}{b} = \frac{2S}{abc} = \frac{\sin C}{c}$.

Therefore, in any triangle

$$\frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}.$$

40. *To prove that* $\tan \frac{B-C}{2} = \frac{b-c}{b+c} \cdot \cot \frac{A}{2}$.

Since $\frac{\sin B}{b} = \frac{\sin C}{c}$. $\quad \therefore \frac{b}{c} = \frac{\sin B}{\sin C}$.

$\therefore \frac{b-c}{b+c} = \frac{\sin B - \sin C}{\sin B + \sin C}$ [Algebra, Art. 139]

$$= \frac{2 \sin \frac{B-C}{2} \cdot \cos \frac{B+C}{2}}{2 \sin \frac{B+C}{2} \cdot \cos \frac{B-C}{2}} = \frac{\tan \frac{B-C}{2}}{\tan \frac{B+C}{2}}.$$

But $\frac{A + B + C}{2} = 90°$.

$$\therefore \tan \frac{B+C}{2} = \tan\left(90° - \frac{A}{2}\right) = \cot \frac{A}{2}$$

$$\therefore \frac{b-c}{b+c} = \frac{\tan \frac{B-C}{2}}{\cot \frac{A}{2}};$$

or, $$\tan \frac{B-C}{2} = \frac{b-c}{b+c} \cdot \cot \frac{A}{2}.$$

Similar formulæ can be proved for $\tan \frac{C-A}{2}$, and $\tan \frac{A-B}{2}$.

41. By the aid of the formulæ in Articles **35** to **40** we can solve a triangle when we are given three of its parts, one of the given parts being a side. These formulæ are therefore very important.

Solution of Triangles

42. There are four cases.
(1) Given the three sides.
(2) Given one side and two angles.
(3) Given two sides and the included angle.
(4) Given two sides and the angle opposite one of them.

43. Given the three sides a, b, c.
From any of the formulæ of Articles **37** and **38**, we can calculate two angles, say A and B. The third angle is $180° - A - B$.

For logarithmic computation these formulæ are adapted as follows:

$$\tan \frac{A}{2} = \sqrt{\frac{(s-b)(s-c)}{s(s-a)}}.$$

$\therefore \log \tan \frac{A}{2} = \mathrm{L} \tan \frac{A}{2} - 10$

$$= \log \sqrt{\frac{(s-b)(s-c)}{s(s-a)}} = \log \left\{\frac{(s-b)(s-c)}{s(s-a)}\right\}^{\frac{1}{2}}$$

$$= \tfrac{1}{2}\{\log(s-b) + \log(s-c) - \log s - \log(s-a)\}.$$

H. J. ALLPORT

The World Trade of the British Isles at the Eve of the Great War

BRITAIN IN BUSINESS

BRITAIN in business with the world is a deeply interesting study. In the BUSINESS group we give a broad sketch of the national economy [see pages 735 and 865], and show how the position of the United Kingdom, as a great and populous country, depends upon the maintenance of export power—power, that is, to secure, by oversea trade, wealth which Nature denies to the British Isles. We now proceed to examine these all-important conditions in concrete.

Our Dependence on Foreign Commerce. The facts we are about to examine are supremely important to every man of business, no matter what his particular line of activity may be. Our dependence upon foreign commerce is so great that foreign products are necessarily built into every part of the framework of our lives. We are clothed almost entirely in foreign fibres; we are housed in buildings in which foreign materials play a conspicuous part; our instruments of work and pleasure are largely fashioned out of woods and metals and other substances earned by us in dealings with persons oversea. The food and fodder consumed by ourselves and our flocks and herds and domestic animals are, as to about one half, sea-borne.

It matters not that a man may be immersed in what appear to be entirely domestic or home operations. In essence he is as fully dependent upon export trade as though he were directly an export manufacturer or export merchant. Whether he be physician, painter, writer, actor, banker, stockbroker, policeman, carpenter, or what not, he lives and works in a great community which is built upon foreign commerce, and which, without foreign commerce, would shrink to the dimensions of a tenth-rate nation living at a much poorer standard of existence than now obtains. It is therefore a matter of the liveliest interest to every man and woman in the country how we trade, where we trade, and why we trade. It is the duty of every intelligent Briton to get a good working conception of one of the most remarkable things in the world—the British national economy. The latest official analysis of British commerce *before the War* is for the year 1913, and we give above a very simple statement of the main facts.

A BIRD'S-EYE VIEW OF BRITISH COMMERCE IN 1913

(The figures represent millions of £.)

CLASS OF TRADE	A Gross Imports	B Imports re-exported	C Imports for consumption (A—B)	D Exports of British goods
Food, drink, tobacco	290	16	274	33
Raw materials ..	282	64	218	70
Manufactures ..	194	29	165	411
Miscellaneous ..	3	1	2	11
Totals for 1913 ..	769	110	659	525
Corresponding Totals for 1912	745	111	634	487

NOTE.—The corresponding totals for 1912 are given for comparison. It will be seen that the trade of 1912 made a considerable advance upon that of 1912. As to the progress of commerce in the past, see the table in BUSINESS, Chapter 7, on page 866.

British Commerce Examined. The statement exhibits the enormous aggregate of British oversea trade as classified in three great divisions: The first, food, drink, and tobacco; the second, raw materials; and the third, manufactured articles, leaving over a small quantity of miscellaneous goods.

The nature of the vertical columns should be very carefully noted. Column A, Gross Imports, shows the total value of the goods imported, and as valued at British ports, including the cost of freight and of insurance from their ports of origin, or c.i.f. (cost, plus insurance, plus freight), as the commercial world terms it. The larger part of these imports is consumed in the United Kingdom, but a part is re-exported, in the same form as imported, by merchants. This re-export, or entrepôt trade, as it is sometimes called, is shown in column B. By deducting column B from column A, we get column C, which thus represents the imports into the United Kingdom for home consumption as distinguished from the gross imports of column A.

We then come, in column D, to the exports of British goods. These consist of British products and manufactures, the manufactures, of course, often being made up of imported materials. Exports, it should be noted, are valued at what is known as "free on board" (f.o.b.) values. They represent the value of the goods as placed on ship at British ports, and they do not include the freight and insurance of the goods to their ultimate destinations in foreign countries and British possessions.

With these necessary explanations, the meaning of the table can be properly appreciated. We see that in 1913 the gross imports of the United Kingdom were £769,000,000, and that £110,000,000 worth of these imports were re-exported, leaving £659,000,000 worth for home consumption. As to exports of British goods, we see that the value of goods shipped from British ports in 1913 amounted to £525,000,000, a record figure for this or any other country.

Imports and Exports Compared. The striking dissimilarity of our import and export trade is clearly brought out by the broad analysis.

As to food, drink, and tobacco, we see that our imports for home consumption were about

eight times as great as our exports—namely, imports, £274,000,000; exports, £33,000,000.

As to raw materials, we see that our imports for home consumption were about three times as great as our exports—namely, imports, £218,000,000; exports, £70,000,000. It should be observed that of the £70,000,000 worth of British exports of raw materials as much as £54,000,000 consisted of coal, leaving only £16,000,000 worth of British exports of raw materials proper in 1913. Thus, apart from coal, our imports of raw materials for home consumption are normally about fourteen times as great as our exports.

As to manufactured articles, we see that exports very largely exceed imports, being as nearly as possible two and a half times as great as imports—namely, exports, £411,000,000, and imports, £165,000,000. Broadly, then, it is true to say that British imports chiefly consist of foods and raw materials, while British exports chiefly consist of manufactured articles.

Turning to the totals for 1913, we see that imports for home consumption were worth £659,000,000, while exports of British goods were worth £525,000,000. It is not only the greatest, it is also the most remarkable, commerce in the world. No other great nation has such a peculiar dependence upon imports. It should never be forgotten that both our exports of British goods and the British goods which we make for our own home market are equally fashioned, in great degree, from imported materials.

In the important table we have reviewed, the great categories into which it is divided—categories which came into use upon the suggestion of the present writer in 1902—are necessarily of a somewhat arbitrary character. It is very difficult to draw the line between a raw material and a manufactured article, and in practice what is the finished manufactured article of one trade is often the raw material of another trade. The category "Food" necessarily includes both crude food products, such as corn or chilled beef, while it also includes manufactured foods, such as sugar and tinned lobster among the imports, and jam and biscuits among the exports. On this head it may be remarked that a very large part of the British exports of food consists of manufactured articles.

As to the big category "Manufactures," the imports and the exports are concerned with large quantities of articles which are partly manufactured, and with finished articles which are bought for use as materials. As to partly manufactured articles, we may note such things as crude copper, iron, zinc, tin, lead, etc., of some of which we import enormous quantities. As to wholly manufactured articles used as materials, we may note such things as leather, paper, and the like, which also figure largely among our imports.

Imports of Raw Materials. Of the gross imports into the United Kingdom in 1913, which, as we have seen, were worth £769,000,000, imports of manufactures amounted to £194,000,000; and among these imports of manufactures may be noted the following huge items representing, not goods brought in ready for the ultimate consumer, but as raw materials of industry.

SOME IMPORTS OF MANUFACTURES CHIEFLY CONSISTING OF MATERIALS OF INDUSTRY

	£
Miscellaneous metals	32,100,000
Chemicals, etc.	12,900,000
Leather, etc.	13,400,000
Paper	7,700,000
Woollen and worsted yarns	3,500,000

The Sources of British Imports. It is next of the deepest interest to see how this mighty oversea trade is divided as between foreign countries and British Possessions. In this analysis we may deal with the figures of 1912, which clearly show the nature of the case.

First, as to the origin of imports. This is clearly and simply shown in the following statement, using the same classifications as before.

UNITED KINGDOM GROSS IMPORTS (1912) FROM FOREIGN COUNTRIES AND BRITISH POSSESSIONS RESPECTIVELY

(In Millions of £.)

Class	From Foreign Countries	From British Possessions	Total
Food, drink, tobacco	200	80	280
Raw materials	193	83	276
Manufactures	164	22	186
Miscellaneous	2	1	3
Total	559	186	745*

* Of this £745,000,000, £111,000,000 was re-exported, leaving £634,000,000 of imports for home consumption in 1912.

We see by this that of the gross imports, amounting to £745,000,000 in 1912, as much as £559,000,000, or 75 per cent., came from foreign countries. From them we draw the greater part of the food and indispensable raw materials which we earn by our commerce. Nevertheless, British Possessions are great and increasing suppliers, and in 1912 we derived from various parts of the British Empire £163,000,000 worth of food and materials. As to manufactures, we see that the greater part of the imports come from foreign countries, British Possessions being as yet not greatly developed as export manufacturers.

Where Britain Sends Her Exports. In the next statement we make a similar analysis of the destinations of the exports of British goods in the year 1912.

UNITED KINGDOM EXPORTS OF BRITISH GOODS (1912) TO FOREIGN COUNTRIES AND BRITISH POSSESSIONS RESPECTIVELY

(In Millions of £.)

Class	To Foreign Countries	To British Possessions	Total
Food, drink, tobacco	20	13	33
Raw materials	15	2	17
Coal	41	1	42
Manufactures	228	157	385
Miscellaneous	6	4	10
Totals	310	177	487

The fine total of £487,000,000 was so divided that approximately two-thirds of our exports went to foreign countries, and one-third to British Possessions. Our coal exports went, of course, chiefly to foreign countries, for our Oversea Dominions are at a considerable remove from our shores, and they can hardly, therefore, import coal from us. As to manufactured articles, foreign coutries are our best customers, but British Possessions are increasingly important ones, and in 1912 it will be seen our exports of this kind to British Possessions amounted to as much as £157,000,000 worth, as compared with £228,000,000 worth sent to foreign countries.

A Grasp of Our Commercial Position Essential. It is, of course, a much easier thing to set out these gigantic totals than to grasp their true significance. We speak of the nation as trading with the various countries of the world, but what really takes place is that individuals in the United Kingdom trade with other individuals in places abroad. It is a thing of extraordinary complexity, this commerce of ours, and it involves operations sometimes lucid and sometimes exceedingly obscure. In some cases a manufacturer directly exports to a foreign or Colonial customer, seeking orders by direct representation, so that he is not only manufacturer but export merchant. In other cases, such direct exportation is unknown or rare in a trade, the export manufacturer relying upon export merchants to secure his orders. Thus it may easily happen that a British manufacturer doing a great export trade has no direct communication with the people who buy his goods, and he may, therefore, remain in complete ignorance of the methods of export trade, and of the machinery by which international transactions are settled. As for the public at large, they see in the shops the foods of oversea origin, and the goods so largely made out of foreign materials, but rarely do they have any opportunity of gaining insight into the real source of the commodities they purchase, or of the materials which compose them. The complexity of modern commerce has been so great, indeed, that goods are not only bought by people who do not understand them, but sold by storekeepers who, in many cases, could not give you an intelligent account of how they came into existence.

There is an element of danger in this position, for the currents of commerce are even more easily changed in modern times than in the old days which saw the rise and fall of many great nations. The study of British commerce should therefore be widely pursued, that the nation should not, amid a mass of complexities and in a fog of obscure detail, lose sight of the vital points upon which the continuance of such a great trade, and the consequent continuance of Britain as a great nation, absolutely depend. For a study of this part of the subject, BUSINESS [page 865] should be carefully consulted.

Food Imports Vital to Us. It will help to a conception of the magnitude of our imports if we remember that, large as our population is, it numbers no more than nine million families. As our imports for home consumption in 1912 amounted to £634,000,000, we see that we imported in that year £70 *worth of foods, materials, and manufactures for each family in the country!*

Our conception of the volume and variety of our imports is further assisted by looking at the matter in more detail. Here is a statement of the quantities of the chief foods imported in the year 1912.

QUANTITIES OF THE CHIEF FOODS IMPORTED: 1912

Wheat	109,600,000	cwt.
Flour	10,200,000	„
Maize	43,900,000	„
Barley	20,100,000	„
Oats	18,300,000	„
Beef	8,600,000	„
Mutton	5,100,000	„
Bacon	4,600,000	„
Butter	4,900,000	„
Cheese	2,300,000	„
Eggs	2,300,000	thousands
Apples	3,900,000	cwt.
Bananas	7,000,000	bunches
Oranges	5,600,000	cwt.
Lard and imitation lard	2,000,000	„
Margarine	1,300,000	„
Cocoa (raw)	75,300,000	lb.
Tea	361,100,000	„
Sugar and molasses	98,200,000	cwt.
Potatoes	5,800,000	„
Onions	9,400,000	bushels
Tomatoes	1,400,000	cwt.

There is a host of other foods imported, but we have dealt with the main items only. This great importation is supplemented by a home production, as to which it may be broadly stated that, taking all kinds of foods together, such as we can produce in our climate, we produce about one-half of what we consume.

Our imports of tobacco amounted to 141 million lb. in 1912, and our imports of wine to 12,200,000 gallons. Of brandy we import 1,400,000 gallons, of rum 4,000,000 gallons, and of gin 1,000,000 gallons, but the chief alcoholic spirit consumed in this country—whisky—is, of course, mainly produced at home.

Imports of Raw Materials. The list of the chief raw materials imported is equally impressive.

CHIEF RAW MATERIALS IMPORTED IN 1912

Iron ore	6,700,000 tons.
Other ores (value)	£9,100,000
Wood	9,700,000 loads.
Cotton	28,000,000 centals (of 100 lb.)
Wool	857,400,000 lb.
Woollen rags	114,600,000 lb.
Miscellaneous textile materials (value)	£18,600,000
Petroleum	413,100,000 gallons
Oils, oil seeds, various (total value)	£37,400,000.
Hides and skins (value)	£13,700,000.
Sheepskin	78,000,000 lb.
Wood pulp and other paper materials	1,200,000 tons
Rubber	1,100,000 cwt.

Here are the chief materials upon which British work is done, with power produced from our all-important coal. In 1912 we imported 2800 million lb. of raw cotton, or over 60 lb. for every man, woman, and child in the country, although the greater part of the cotton goods

made from it are exported. As to raw wool and woollen rags, we imported over 20 lb. per head of population. Of timber, a load was imported for every family in this country, and the importation of 413 million gallons of petroleum in various forms is another extraordinary item.

As to metals other than iron, we import them chiefly extracted from their ores, so they do not appear in the above list. In 1912, it may be remarked, we imported over £31,000,000 worth of miscellaneous metals, chiefly in an unmanufactured form, and without these our brass and other metal industries could not continue.

As will have been gathered from the broad anaylsis of our imports already given, we lay all the world under tribute for the wealth which enriches us, and which we have seen to be largely foreign to these islands.

The Wheatfields that Feed Us. From period to period, as the world develops, the sources of our imports undergo change and modification. A striking illustration of this fact is to be found in regard to corn. Not many years ago we derived the greater part of our wheat supplies from one country, the United States. In 1912, although the United States was still a considerable supplier, she supplied only about one-fifth of our wheat. Here is a comparison of 1902 and 1912, which will show that remarkable changes have taken place in the sources of our imported wheat.

WHEAT IMPORTED INTO THE UNITED KINGDOM
(FLOUR INCLUDED IN EQUIVALENT WEIGHT OF GRAIN)

SOURCE	1902	1912
	Cwt.	Cwt.
From Foreign Countries :		
U.S.A.	65,000,000	25,800,000
Argentina	4,500,000	18,900,000
Russia	6,600,000	9,000,000
Other countries	6,400,000	4,400,000
	82,500,000	58,100,000
From British Possessions :		
Canada	12,200,000	27,100,000
Australia	4,200,000	12,900,000
India	8,800,000	25,400,000
Other British Possessions	200,000	200,000
	25,400,000	65,600,000
Total : All the world ..	107,900,000	123,700,000

In 1902 the United States furnished 65 million cwt. out of a total of 107,900,000 cwt. of wheat imported by us. In 1912 our imports had risen to 123,700,000 cwt., but the United States supply had fallen to 25,800,000 cwt. Fortunately, other countries, especially Argentina, Canada, Australia, and India, redressed the balance, but the falling off in the United States supply has meant a rise in the price of corn.

This table may be taken as a typical example of the need in our day to keep a constant and watchful outlook upon world developments. There is an accelerating swiftness of movement in commercial developments. It is now possible for a country to build up a new trade in ten years to considerable dimensions, and almost to lose it in another ten years. Even to be pioneers in a trade counts for little in the twentieth century. For example, the French were pioneers in the motor-car industry, and for some time held the lead, but they have now fallen behind in an industry which they can claim to have invented. Those who are not prepared to march swiftly with the times after the Great War will find themselves beggared by new competitors.

The statement we have just given with regard to corn, taken together with the analysis of imports generally, goes to show that British Possessions are gaining upon foreign countries as suppliers of our imports. Indeed, the movement in this connection has been very rapid.

Cotton. With regard to our supplies of materials, our dependence for raw cotton upon the United States is still a remarkable thing. In 1912 we imported 28 million centals (100 lb.) of cotton. Over 27 million centals came from foreign countries, and of these 55,200,000 centals came from the United States, Egypt supplying 20,800,000 centals. Of late years a little has been done by the British Government to assist systematic development of cotton-growing within the British Empire, but much more needs to be done. There is very great danger in the cotton position so long as the present circumstances remain. The development of American cotton manufacturing under a saner fiscal system, and with the assistance of the Panama Canal and the remarkable changes which it will make in trade routes, is likely to proceed apace. It is possible, therefore, in the course of another ten or fifteen years, that America will be absorbing all the cotton that she produces. In short, we may expect to occur in American cotton what has already occurred in American wheat. Should that prove to be the case, the position of Lancashire will be deplorable if, in the meanwhile, cotton-growing within the British Empire has not reached considerably greater dimensions. We may have here another instance of swift modern development inimical to our commercial interests.

As to timber, we have an obvious duty to perform, and that is to raise as much as possible upon those millions of acres in the British Isles which are quite suitable for the purpose, for timber is now steadily growing dearer.

The Empire must Look Ahead. The time has come when it should be our business to remember that the British Empire is a great trust, which it is our duty to administer in conservation of its wealth, and for the mutual benefit of its various parts. When we consider Britain in business with the world, this side of the subject assumes a great and growing importance. The time is surely coming when the world as a whole will have to have a stern regard to its limited resources; and in view of the fact that the British Empire forms so considerable a proportion of the world we have a special and grave responsibility. L. G. CHIOZZA MONEY

THE DIVER PHOTOGRAPHED IN MID-AIR

AN EXAMPLE OF THE HIGH SPEED ACTION OF THE MODERN KODAK CAMERA

FACING PAGE 5933

Cameras, Lenses, and Plates. Intensifying and Reducing. Enlarging. Lantern Slides. Carbon Printing. Flashlight Work. Press Photography.

DARK-ROOM PHOTOGRAPHY

Plate Cameras. Cameras for use with dry-plates may be roughly divided into three classes, according to whether they are for use in the hand or on a tripod; these three classes are hand, hand or stand, and stand. In the hand cameras the subject to be photographed is seen only in the finder (except in the *reflex cameras*, where a full-size image is projected by means of a mirror on a screen in the top of the camera). In the hand or stand cameras there is a finder, for use when hand exposures are made, and a focussing screen at the back, where the image is seen exactly the size it will appear in the finished picture, but upside down. In the stand cameras, however, there is no finder or focussing scale; the image is seen only on the focussing screen.

Sometimes the user of a plate camera wishes to have the advantage of the lightness of films. He then buys a Premo Film Pack Adapter, at a cost of a few shillings, which takes the place of his ordinary dark-slide. Into this adapter he places the Premo Film Pack, which holds a dozen flat films, and which can be loaded and unloaded in daylight.

Generally speaking, the photographer should buy the highest-priced camera he can afford. Although this advice is given, it must not be thought that the more expensive the camera the better the photograph that can be taken with it. Very much more depends on the photographer than on the camera. It is quite possible to take as good a photograph with a five-shilling camera as with a five-guinea one. But the limitations of usefulness are narrower on the cheaper camera, and it will, of course, not be so well constructed, and will therefore not last so long. The cost of a camera depends chiefly on the lens with which it is fitted.

The Choice of a Lens. The lenses fitted to cameras are of three kinds, single, rapid rectilinear, and anastigmat. The single lens is usually fitted to the cheaper types of cameras; sometimes it is listed as a *meniscus achromatic*. Single lenses have to be worked at a small aperature, or else they do not give a sharp image. Working at a small aperture, they do not pass very much light, and consequently are slow. They also show distortion in photographs where there are straight lines near the edges of the subject.

Rapid rectilinear lenses, frequently abbreviated to R.R. lenses, overcome the two chief failings of the single lens. They work at a larger aperture, and consequently are faster; they also overcome distortion. The chief failing of the rapid rectilinear lens is that the image is likely to "fall off" in sharpness near the corners of the negative unless it is worked at a small aperture. Medium-priced cameras are usually fitted with a rapid rectilinear lens.

The best lenses are the *anastigmats*. They do not have to be "stopped down" to a small aperture in order to get good definition, and they work at high speeds

Plates. Plates are made with varying degrees of sensitiveness. In the "Royal Standard" plates, for instance, there are the rapid, extra rapid, special extra rapid, and lightning. As a general rule, the amateur will find it better to work with the slower speeds at first; the very rapid plates had better be left until he is thoroughly proficient with the slower. Sometimes the beginner blames his plates when he is not getting satisfactory results, but almost invariably the fault is in his working, and not in his materials. One frequent cause of trouble is that the dark-room light is not really safe. There may be chinks through which daylight enters, or the lamp itself may pass rays of actinic light. This is shown by the negative being "veiled." The edges, or the "rebates," as they are called by photographers, should be perfectly clear; if they are not, it is a sign that the light of the dark-room is not safe. Then again, markings in negatives are frequently put down to faults in making the plate, whereas they arise from a fault which the photographer little suspects—that is, dirt. In the dark-room absolute cleanliness must always be observed. And directions should always be carefully followed. If a formula says that a certain substance has to be dissolved, it must be thoroughly dissolved; imperfectly dissolved substances account for a lot of the markings in negatives.

Developing formulæ are not given here, because every packet of plates gives the formula which the makers have worked out as the best for the plates contained in the packet.

Correct Colour Rendering. Certain plates, variously called chromatic, isochromatic, or orthochromatic, are more sensitive to green and yellow than ordinary plates. When a yellow screen is placed on the lens, the plate's excessive sensitiveness to blue it reduced, and so a negative is obtained in which white clouds are shown in their proper relation to blue sky. But if absolutely correct colour rendering is desired, it is much better to use such a plate as the Wratten "Panchromatic," which is not only sensitive to green and yellow but also to red. The best screens are those which are made by the makers of the Wratten Panchromatic plates, and sold under the name "K" filters.

After-treatment of Negatives. The head of an important photographic business once told his staff that there were no such things as intensifiers or reducers! He went on to explain that if their first negatives were not so good as they should be, they must take them again. If there was not time to take them again, they must choose a printing-paper which would give a good result from the poor negative. Many amateurs would be surprised if they know how little intensifiers and reducers are used by professional photographers. The great thing is to endeavour to get a correctly exposed and developed negative in the first place, and only to use intensification or reduction as a last resort. Another point is that negatives should always be thoroughly fixed and washed before treatment.

Intensifiers. What treatment is given depends on the fault to be remedied. If the negative is under-exposed, it will be shown by absence of detail in the shadows. The *uranium intensifier* should be used, made up as follows:

A. Uranium nitrate	100 grains
Water	10 ounces
B. Potassium ferricyanide	100 grains
Water	10 ounces

Take one ounce each of A and B, and add two drachms of acetic acid.

If the negative is under-developed, there will be detail in the shadows, but the whole image will be too thin. The *chromium intensifier* is then the best. Bleach in the following:

Potassium bichromate	5 grains
Hydrochloric acid (1.160)	1 minim
Water	1 ounce

Wash until the yellow stain is removed, and then develop (by daylight, or after exposure to daylight) with amidol.

Reducers. Sometimes a negative gives "soot and whitewash" prints, generally caused by over-developing a plate which has been slightly under-exposed. The ammonium persulphate reduces the density of the high-lights without attacking the detail in the shadows.

Ammonium persulphate	5 to 10 grams
Water	1 ounce

After reduction, the plate should be placed in a 5 per cent. solution of sodium sulphite for a few minutes, to stop the action of the reducer.

If the negative is dense all over, and takes a long time to print, Farmer's reducer should be used, but remember that it is poisonous. A 10 per cent. solution of potassium ferricyanide is added to hypo solution until it is pale yellow. The negative must be thoroughly soaked before placing in this solution. As soon as sufficiently reduced, the negative must be thoroughly washed.

Enlargements by Daylight. When we have made some successful small pictures, we are sure to become more ambitious, and anxious to make larger pictures. To do this it is not necessary to get a larger camera, but we can supplement our small camera with an enlarging camera. There are two kinds of cameras for enlarging, one for daylight and the other for artificial light. A daylight camera which will enlarge from quarter-plate size ($3\frac{1}{4}$ in. by $4\frac{1}{4}$ in.) to whole-plate ($6\frac{1}{2}$ in. by $8\frac{1}{2}$ in.) can be bought for a few shillings, so that the initial expense is not very great. We must, however, buy larger dishes for the larger size of paper. In the daylight enlarger of fixed focus, enlarging from quarter-plate to whole-plate, the light passes through the negative and then through a lens, so that the image is projected upon the printing-paper fixed at the other end.

Enlarging bromide paper is, as a rule, very sensitive to light, so that the packet should be opened and the enlarging camera loaded only in the dark-room. Those who have already mastered gaslight printing by contact will make successful enlargements at once, as the same kind of paper is used. The length of exposure depends on the strength of the light and the speed of the paper. Owing to the expense of waste, it is well to make test exposures in the camera with small pieces of paper before risking a whole sheet. The makers of paper now recognise this by enclosing an extra piece, quarter-plate size, which may be used for preliminary test.

Formula for amidol: amidol (or diamidophenol), 80 grains; sulphite of soda, 2 oz.; water, 12 oz.; bromide of potassium, 15 grains.

This has to be made up fresh for each printing, and deteriorates in about ten hours. The bromide of potassium makes the developer a little slower, but brightens the prints. A negative that may print rather thin and flat with P.O.P. may give bright prints in an enlargement if we under-expose and use a strong solution.

Artificial Light Enlarging. But by far the most satisfactory method of enlargement is by artificial light. Here our light is always of the same strength, whereas daylight is constantly changing. Another great advantage is that we can control the printing. For instance, we may have a negative of an interior lit up by a window or flashlight on one side. By placing a piece of cardboard in front of the thinner portions of the negative, we can to a large extent rectify this unevenness of lighting, and make a presentable print.

Another advantage about the artificial enlarging lantern is that it may be used as a magic-lantern, and we can amuse our friends by throwing our pictures on the screen.

The cost, however, of the artificial lantern enlarger is greater than the other, since a "condenser" or larger lens for concentrating the light has to be used. This in itself is so expensive that a reliable enlarger can hardly be bought new for less than three guineas. We can, however, often pick one up secondhand for rather less. The photographer who wishes to go in for Press or professional portrait work later on will find this artificial light enlarger absolutely necessary.

In the enlarger for use with artificial light the light, which is usually an incandescent or electric light, preferably the former, is behind the condenser, and the condenser concentrates the light on the negative. Through the negative the light passes on to the lens, and the image is thrown into focus on bromide paper, either fixed on a slide or pinned on a board fixed upright at the requisite distance. We require no elaborate stand for our enlarger, but can prop the spare leaf of our dining-room table against the wall of the dark-room and set the enlarger on two wooden chairs of equal height. An arrangement for focussing enables us to enlarge to any size or in any proportion we desire. If by any chance we have tilted our camera by mistake, and so got the lines in the wall of a house slanting, we can stop down the lens in the enlarging camera, and tilt the support of the paper slightly, so as to correct this awkward mistake. We can very often improve our negative by enlarging only the interesting portion of it. A sharp negative will enlarge many diameters without showing any trace of enlargement. Experienced tourists know this, and often prefer to take with them only a quarter-plate camera, knowing that they can enlarge their good negatives to any size at home.

Hints for Enlarging. The lens in the enlarging camera should always be stopped down a little, as this tends to give a brighter print. The utmost care should be taken to keep the hands perfectly clean in printing, otherwise the paper will show stains. It is always advisable to "clear" an enlarged print, as the paper, especially if of glossy surface, is inclined to show markings, due in no way to the operator. This clearing solution is the same as the reducing solution (ferricyanide of potassium) mentioned already. Dip a piece of cotton-wool in this, and gently rub the surface of the paper while still damp. This will clear the whites wonderfully, and will even remove slight yellow stains due to previous carelessness.

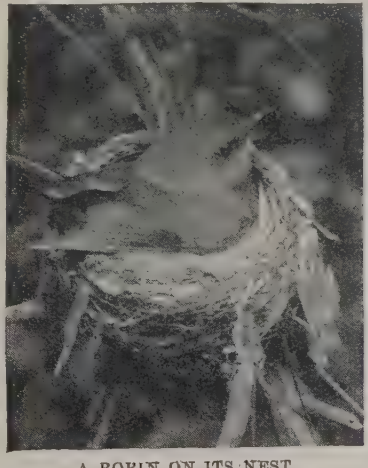
We can focus accurately on the paper by placing in front of the lens a yellow glass cap, which is removed for the exposure. These caps are stored by any dealer who has enlarging cameras. All

SOME EXAMPLES OF PLATE PHOTOGRAPHY

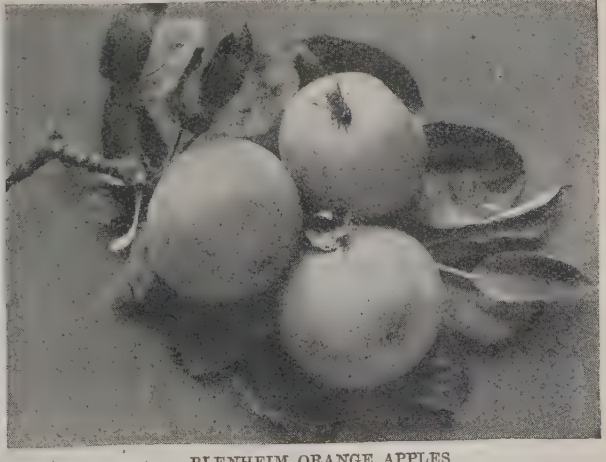
A STUDY OF FISHING-BOATS

THE LION BY NIGHT

A GROUP OF YOUNG CROCODILES



A ROBIN ON ITS NEST



BLENHEIM ORANGE APPLES

These photographs are reproduced by courtesy of the Imperial Dry Plate Co.

white light, however, should be excluded from the room, as the bromide paper used for enlarging is sensitive to the light, far more so than is generally supposed. If we want to be sure of good prints, we must run no risks. Do not expose the print after development to any other than the light shown through this yellow glass till the print has been at least five minutes in the hypo (fixing) solution, or we risk getting it fogged.

Lantern Slides. Lantern-slides are very easily made, without special apparatus, by contact printing. They are really positive prints made on glass instead of a paper support. We will probably find among our negatives a number in which a square of 3¼ in. makes a good picture. This is the size of the lantern-slide. The positive is made by contact in the same way as in the case of gaslight papers, but it is well to clear the slides for the sake of improved transparency after development and fixing, and before washing. Here is a well-known formula for *clearing solution:*

Protosulphate of iron, 3 oz.; alum, 1 oz.; citric acid, 1 oz.; water, 20 oz., or in proportion. The depth to which a lantern-slide should be developed can be gauged only by experience. If, however, we study a good lantern-slide, such as we often see in an optician's window, or such as are sold for educational purposes, we can save ourselves much trouble and waste.

If we wish to secure the whole of our negative on our lantern-slide we can still do so without special apparatus. We must block up the whole of a window lighting a room with dark brown paper, leaving only a hole the size of our negative. Into this hole the negative is fixed, say, by means of sticking-plaster over the corners. We must now photograph this negative on a prepared lantern-plate, focussing accurately and getting the image as near 3¼ in. at its widest part as possible. We should stop down our lens to at least F/22, and back our plates with backing-paper, which may be bought at 6d. a box. The lantern-slide plates will fit into the sheaths of our camera, but must, of course, be fixed in the middle of the sheath, otherwise the picture may overlap the plate.

The positive plate has to be mounted before it is a complete slide, otherwise the film would be quickly destroyed by the heat of the lantern. Cover-glasses, made of very thin glass, and of the same size (3¼ in. by 3¼ in.), are placed so as to cover the sensitive side of the positive, and the two glasses are bound together by binding strips round the edges. This binding is quite easy to do.

More Advanced Work. Although a great deal may be done with a quarter-plate combined with an enlarging camera, we may be pardoned if we grow still more ambitious. The average lens, even in expensive quarter-plate cameras, has so short a focus that distortion is difficult to avoid. By *focus* we mean the distance in the camera between the centre of the lens and the photographic plate. The human eye is said to have a lens corresponding to one of 16 in. focus, but the quarter-plate camera is satisfied with 4½ in. or 5 in. It is, of course, possible with a focussing camera to adapt a telephoto lens, such as the "Adon," to overcome this objection, but for many reasons we should do better still with a good half-plate camera. It is a good plan to get a camera with a double anastigmat lens, in which the front and back portions of the lens (each of different focuses) can be used separately or in combination, giving us the choice of using short or long focus lens at will. Thus, a combined lens which has a focus of 6½ in. may consist of a front portion with focus of 14 in., and a back portion with focus of 9 in. The camera that is to hold such a lens must, of course, have a bellows capable of extending to 14 in. In the case of portraits, the longer the focus the better. A curious fact also is that a large lens seems to give more modelling and to get round the objects more than a small lens of the same focal length.

Carbon printing and the subsidiary processes so much affected by artistic workers are hardly worth attempting in less than half-plate size. It is, of course, possible to make enlarged negatives and to print from these, but, after all, the best method of making enlarged negatives is by the carbon process.

Carbon Printing. The chief makes of carbon tissue—the Autotype Co. and Elliott & Sons—supply such elaborate directions that it is unnecessary here to give more than a brief outline of the process. A good plan is to experiment with the Trial Set supplied by the Autotype Co., or the Sample Set supplied by Elliott & Sons.

The principle and method of carbon printing are so simple and the results so artistic that we can well understand why it has taken the foremost place both in amateur and in professional photography. We may begin by explaining how the image is made in the carbon tissue. It has been discovered that gelatin combined with bichromate of potassium becomes more or less insoluble according to the amount of light to which it is exposed. When a prepared gelatin tissue is exposed to the light under a negative it becomes insoluble in depths which vary according to the strength of the light which the negative allows to pass through its parts. A small amount of light passes through the whole of the negative, and therefore the whole of the surface of the tissue is affected and becomes insoluble. The problem is, how are we to get to the lower layers of the tissue, so that we can dissolve away that which has not yet been affected by the light? This is done by transferring the tissue from the paper on which it is originally mounted to a new support, face downward. When this transfer is made, the soluble portions now exposed can be cleared off by the application of warm water, and the positive image—made of insoluble gelatin—brought to view.

The Single Transfer. In the single-transfer method of carbon printing—the simplest, and therefore the best to begin with—the image is reversed from left to right, but very often this does not matter. The sensitive tissue is usually made up twice a week by the companies that supply it, and should be used within nine days, as it does not keep. Prints should be made in dry weather only. The safe-edge mask—supplied in the Trial Set—must always be applied round the edges, otherwise the transfer is apt to be unsatisfactory. No image is seen at first in the printing, so that an actinometer for measuring exposures has to be used. A simple actinometer is supplied with the Trial Set. The time required for printing is considerably less than that for P.O.P., and the action of the light continues—at a reduced rate—after the tissue has been taken out of the frame. We may turn this continuing action to advantage in the case of prints which are suspected of under exposure. If these are kept for twenty-four hours before development they may turn out all right.

The single-transfer paper is slightly larger than the mounted carbon tissue. It is placed face upwards

CAMERA STUDIES OF HAPPY CHILDREN

THE SMILE

ON THE BEACH

A LITTLE GIRL AND HER FRIEND

These photographs are reproduced by courtesy of the Imperial Dry Plate Co.

in a tray of cold water at about 60° F., and all air bubbles must be carefully removed. We should have a depth of at least 1½ in. of water in the tray. Then the exposed tissue is placed face downwards in the water, and the fingers gently slid along the surface underneath tore move air bubbles. The tissue will flatten out, and then begin to turn up at the edges. The tissue and the transfer paper are now brought into contact under water and taken out together, and then squeegeed into perfect contact with a scraper squeegee such as is supplied with the Trial Set. The two sheets are now put between blotting-paper, and laid under a heavy weight, such as a large book. This secures uniform pressure. All the prints are treated thus, and left under pressure for about half an hour or till the back of the transfer paper has turned yellow.

Developing with Water. For development, two baking-tins, costing about a shilling each, will do. But we must not use these tins afterwards for baking, as bichromate of potassium is a strong poison, and the success of our printing should make us desire to live a little longer. Fill a tin with water heated to 90° F. to 100° F. The gelatin soon begins to ooze out at the edges. Then transfer the sheets to a tray of slightly hotter water, 100° F. to 110° F., about 1½ in. deep. Holding the combined sheets under water, lift up a corner of the tissue sheet and gently strip it off. If it does not strip off readily, leave it a little longer and try again. The gelatin is now transferred to the new support, and the lower soluble layers are exposed and can be treated. The transfer paper, to which the tissue now adheres, is placed on a slab or flat dish at an inclined angle, and laved with water at 100° F. to 110° F. by means of a teaspoon. Gradually the image will appear as the soluble part is washed away. We lave it till it is a little lighter than we desire the finished print to be. The water can be kept at an even temperature by placing the tray on a gas-stove with the gas-jet at the proper height. If the tissue has been over-exposed, it does not easily dissolve, and still hotter water must be used. This, however, must be used with care, as it is apt to cause blisters.

The great charm of carbon printing is that local development can be carried out easily. A sky that would otherwise be lost can be saved by developing the upper portion of the picture in cooler water than the lower, and over-exposed portions can be reduced by careful laving with hot water, or the local application of sulphocyanide of ammonia.

When the print has been sufficiently developed it must be cleared and hardened. A filtered 5 per cent. solution of powdered alum in water is the bath. This clears away the yellow stain and hardens the film, after which the prints should be washed for half an hour in running water, and then hung up with clips to dry.

Double Transfer and Modifications. In the double-transfer method, a temporary support is used instead of the single-transfer paper, and from this temporary support the image is transferred to a final support. This double transfer restores the image to its natural position. For making enlarged negatives, a special transparency tissue is made, which requires half more exposure than the ordinary kind. This is transferred by the single-transfer process to a glass support, and printed through an enlarging camera on to a negative of the size required. The image is reversed to its natural position by keeping the tissue side of the glass towards the source of light.

Modifications of the carbon process avoid transfer, but usually require us to sensitise our own solution. On the whole the old method is the most satisfactory of all printing processes, and we do not grudge the slight extra trouble.

The Press and the Editor. Photography for the Press contains more of the element of uncertainty than any other branch of the craft. If you are actually on the staff of a paper, this uncertainty is, of course, diminished, but between the free-lance and success a thousand chances intervene. Still, it is one of the most interesting, and often one of the most profitable, forms of using the camera. A very skilful and successful photographer for the Press acknowledges that, after paying all expenses, he clears about £500 a year. It must be remembered, however, that he is at the top of the tree, and has fifteen years of hard work behind him. The main point to remember is that we cater not so much for the public as for our editor. We must give him the kind of print and subject he wants, not what is intrinsically best. Very often we shall find our best work thrown on our hands, owing to his personal tastes, or the space he may have at his disposal. "Better luck next time," we must say— and try again.

In the first place, it is advisable to make our prints not less that half-plate size, and with a glossy surface, which may even be squeegeed. The reproduction the editor may make may be only 3 in. by 4 in., but he personally likes to see the prints large. For this reason, most Press photographers use a half-plate camera, so that they can readily run off contact prints, and in many cases they print through the enlarging camera on glossy bromide paper, submitting pictures whole-plate size. The glossy surface is not really necessary for reproduction, and some engravers actually damp their paper to get rid of the gloss before making their block, but few editors know this, and prefer the print which apparently shows most detail. There are, of course, exceptions, and "Country Life," for instance, takes artistic photographs even on rough surfaces. This extreme, however, is only possible in the case of a magazine with very fine printing.

Camera for Press Work. The most convenient all-round camera to use is a light, folding half-plate camera with a focal plane shutter giving exposures down to 1000th part of a second, and either slides or a magazine containing 12 plates. Our outfit will cost us about £20. The lens should be able to work well at F/6·3., or if possible F/5, and the finer the lens the more likely we are to achieve success under all conditions of weather. We must be prepared to make bright, contrasty pictures at seven in the morning on a rainy day. One of the most successful Press photographers uses a lens with 10 in. focus, but this requires more experience in accurate focussing than, say, a Goerz-Anschutz with lens of 7 in. focus. Some get over the difficulty by having both a long and a short focus lens. This, of course, requires a camera that can be adapted to different lenses. It must be remembered that, especially in sporting photography, we have to snap at a distance from the object required, and yet our figures must be as large as possible. We do not recommend the reflex type of camera for general work. Many of the most skilful Press photographers do not even use a finder, but gauge by experience the view taken by the angle of their lens, and point the camera breast-high at the person or object required. In snapshotting celebrities, this is often the only practical method. We have to keep our

eye glued to our victim, and at the same time have the whole field in view, otherwise we may miss the characteristic attitude, or someone will step in front at the critical moment. In a crowd we may even have to hold our camera above our head.

In addition to the snapshotting of news events there is also a vast field of magazine work. Skill in portraiture is also a great advantage, as the illustrated newspaper of today becomes more and more personal in its interests. One successful photographer has made a speciality of doing for the Press artistic portraits of celebrities at home or in their natural surroundings. The chief London photographers naturally acquire numbers of portraits which are in demand with editors. So much is this the case that they sometimes have to retain a special staff for running off prints for the Press.

Celebrities. So much are celebrities photographed nowadays that few copyrights are worth more than ten guineas at the outside. The usual fee for reproductions of photographs of any sort by an illustrated paper is 10s. 6d. per print for reproductions up to 6 in. by 4 in., and a guinea beyond that size. Reduction in price is frequently asked and granted for a series or set of photographs, but the half-guinea is a useful standard, fair alike to editors and photographers. Occasionally an editor will offer to buy exclusive rights in a photograph for a definite period, when we may get from one guinea to ten guineas. Such occasions and such editors are rare.

Advanced Flashlight. The Press photographer must be master of flashlight work, as the subjects required—especially in magazine work—have often to be taken under difficult lighting. A small room may be lit up sufficiently by magnesium powder or a flashlight candle, but it is advisable to know how to manipulate more powerful flashlights. There are several kinds of explosive powders used in advanced flashlight work, but the safest, and at the same time one of the most brilliant, is *argentorat*, which has the merit of not being set alight by percussion. It is so highly inflammable that it must be handled with great care, and must not be lighted with a match held in the hand. Also, it must not be used in a closed lamp, such as is used with magnesium powder, but in an open metal tray. A handy portable lamp for use with these special flashlight powders is the Weiss lamp, in which a match, close to the powder, is ignited by pulling a string. Another lamp ignites the powder by means of an electric spark.

So vivid is the light of a powder such as argentorat that people jump out of their seats, and they should therefore be cautioned in advance that there is no danger. The flash is so rapid that the photograph is taken before the movement occurs. The smoke is, unfortunately, a great nuisance, and our flashlight may occasionally bring up the fire brigade on a false alarm. Scrape the ash carefully off the tray after each flash, otherwise your later flashes will be accompanied by loud explosions.

Sale and Speed. Country photographers often find it convenient to sell prints through the Press photographic agencies. These send representatives round the chief editorial offices, charging 15 per cent. to 25 per cent. commission. In the case of news photographs, where there is no time to run off many prints, these agents are very handy, as one editor may have special reasons for refusing good prints, for which another has space. In the case of news pictures, speed is half the battle. Pictures of an event that happens on a Monday morning should be submitted, if possible, the same afternoon. Methylated spirits of good quality enable one to dry prints and negatives very rapidly.

Mr. F. C. Bowden, of Bowden Bros., perhaps the most skilful sporting photographer in this country, has kindly sent us the following hints for those who intend going in for such work.

1. Get your figures as large as possible. Avoid having a heavy background of trees when taking fast exposures. They look artistic in the finder, but don't reproduce well, owing to under-exposure.

2. Don't keep changing your brand of plates. Start with a good make, and use only the fastest for extreme exposures. It does not do to use the slower and cheaper make, as the results cannot be obtained with these.

3. When developing, avoid using too much ruby light. The less the better.

4. Don't be impatient with very fast exposures when developing. Anybody can press the button and take a picture in a 1000th part of a second, but it is not everybody who has the patience to develop a plate for an hour or two, as is often the case in winter.

5. A lens working at a large aperture, say F/5·6, is essential.

6. Don't press the shutter release on camera with a jerk.

7. Rehearse in your mind what you are going to do; and when the moment arrives, do it.

Professional Portraiture. The best guide to those who intend to take up professional portraiture is naturally one who has himself succeeded. Mr. E. C. Elliott, of the firm of Elliott & Fry, gives some practical advice on the subject. "Don't try at first to get into a big London house," he says. "Get into a good, moderate-sized provincial house where everything is done under one roof. At Elliott & Fry's, for instance, every department is specialised, and it would be difficult for one to get that general grasp of a business which is essential for a man who intends eventually to set up for himself. After one has realised what one is best fitted for, one may decide to specialise, for instance, as an operator or a printer, a retoucher, or finisher. If you decide to set up for yourself, you must be up to date, and a little before it. I don't know that it is advisable to start with a partner. Partnerships are very uncertain things, and I think that, at any rate to begin with, a clever man with a capable staff can manage by himself. Wherever you are, you must adapt yourself to your locality. A seaside or suburban photographer has quite a differente clientèle from that of Elliott & Fry, and yet may do excellent business. The things to remember are that, whatever your kind of photography may be, you should try to be good of your kind, and that you should not cut prices. You must be up to date in the getting up of your mounts, in printing methods, framing and displaying, while such small details as price-lists, packing of pictures, labels and notepaper should be studied, with a view to making them as attractive as possible. Every young professional photographer—in fact, every photographer, young or old—would do well to become a member of and support the Professional Photographers' Association, and so have at his disposal, in all matters of difficulty which may arise, the help and advice of a committee of the most experienced men in the profession."

WHAT MAN CAN MAKE OF THIS BARE EARTH

A CORNER OF THE LOVELY GARDEN AT "WIGGIE," REDHILL

THOUSANDS OF VISITORS TO REDHILL HAVE CALLED AT THE LOVELY GARDEN OF MR. ARTHUR TROWER, WHOSE GATE IS ALWAYS OPEN TO THOSE WHO LOVE NATURE

Roses, Lilies, Chrysanthemums, Carnations, and Sweet Peas. Bulbs. Tall, Dwarf, and Bedding Plants and Flowers. Ferns. Orchids. Glasshouses.

FAVOURITE GARDEN FLOWERS

A YOUNG gardener is sure to be called upon to pay special attention to the five favourite garden flowers: the rose, lily, chrysanthemum, carnation, and sweet pea.

The Culture of the Rose. The rose has often justly been called the "Queen of Flowers," and it is well to remember that her Majesty requires regal treatment. Failure with roses is generally due to the fact that they are planted in the wrong sort of soil. It is impossible to get good roses in bad ground, and, where the soil is not suitable for their cultivation, it must be taken away, and proper material introduced. The soil in which the rose thrives best is a good rich loam two or three feet in depth, resting on a subsoil of clay. The clay subsoil, being impermeable, retains all moisture, and so keeps the roots of the roses cool during the hot months of summer. Where the soil is very light it must be made heavier by the addition of thick, heavy loam and clay, otherwise the gardener is merely courting failure. Roses are generally grown in the forms of "Standards," "Dwarf Standards," "Bushes," or "Climbers."

A standard is a rose which has been grafted on to a stem about three feet in height. A dwarf standard has been grafted at about half that distance, while a bush usually springs from the ground without showing any main stem at all, having been grafted close to the roots. Roses on their own roots—that is to say, roses that have not been grafted at all—are invariably grown as bushes.

Roses are usually grown as standards when extra large-sized blooms are required for exhibition purposes, or where space is limited. In places where plenty of room is available there is no doubt that the easiest way to grow the rose is in its bush form, as it blooms far more freely under these conditions.

The Best Varieties of Roses. Roses are divided into several sections, or groups, the most important of which are: Teas, Hybrid Perpetuals, Noisettes, Hybrid Teas, Bourbons, Monthly roses, and Ayrshires, titles which are derived chiefly from the land of their birth, or the time of flowering. Altogether there are over two thousand varieties in cultivation, and the number is added to every year.

The following twenty-four sorts recommended by "The Century Book of Gardening" as suitable for town and suburban culture are, perhaps, as judicious a selection as could be made for all purposes:

Red: General Jacqueminot, Alfred Colomb, Abel Carrière, Dupuy Jamain, Cheshunt Hybrid (climber).

Pink: Mrs. John Laing, Baroness Rothschild, La France, Captain Christy, and Pink Rover (climber).

White: Boule de Neige, Merveille de Lyon, and Aimée Vibert (climber).

Yellow: Marie van Houtte, Madame Hoste, Emily Dupuy (climber), and Medea.

Apricot: Francisca Kruger, Safrano, Rêve d'Or (climber).

Salmon: G. Nabonnand, Bouquet d'Or (climber), Dr. Grill, and Felicité Perpetuel (climber).

For town gardens, however, the following sorts should on no account be omitted: Frau Karl Druschki (white), Caroline Testout (pink), Lady Waterlow (pink), Gloire de Dijon (yellow), William Allan Richardson (apricot).

How to Propagate Roses. The three chief methods of propagating roses are by grafting, budding, and cuttings. Grafting [19] and budding are usually performed upon the stem of a wild briar whose sturdy growth makes it eminently adapted for the purpose. This briar is called a stock, and the main stem is cut down to the desired height of the standard, or bush, as the case may be. A V-shaped notch is cut in the top of the stock, from one to three inches deep, according to its diameter. The end of the graft (the rose which it is desired to propagate) should be cut wedge-shaped in order to fit the notch in the stock, and carefully inserted, the junction being thickly covered with clay to afford protection. The operation of budding consists in lifting, with a very sharp knife, a bud, and about a quarter of an inch of the bark round it, and inserting it in a stock. The stock is prepared by cutting a T-shaped slash in its bark, raising the bark gently with the knife, so that the bud may be inserted underneath it, and, when once the bud is in position, binding it round fairly tightly at top and bottom, to ensure its retaining its position.

Cuttings are slips taken off with a slanting cut, and containing two or three "eyes." They are best potted up in small pots in a mixture of sand and leaf mould. If put in a frame and well exposed to the sun they will root in about a month, but must be kept free from frost all the winter, and gradually hardened off the following spring.

The operation of pruning roses is carried out in the spring, and is better performed with the secateur than the pruning knife. Climbing roses do not, of course, require so much pruning as the standard or bush sorts. Probably no two rose-trees require exactly the same sort of pruning, but the golden rule to be observed is to see that the branches in the centre are well thinned, so that light and air have free access.

The best time for planting roses is from November to March—the earlier the better. All newly-planted roses should have protection from frost during the winter months. This may be afforded by a mulch of straw, bracken, or similar material.

The Lily. Though not so popular as roses, perhaps, lilies of varied sorts must be found in profusion in every garden which pretends to be at all representative.

Generally speaking, lilies do not like a heavy soil; consequently, with the exception of a few varieties, the heavy clays which are to be found so frequently in the neighbourhood of large towns and cities are not calculated to grow them to the best advantage. A light rich soil, with plenty of sand and leaf-mould in it, is what the lily revels in, and it is one of the few flowers which has no liking for the presence of animal manure.

Lily bulbs should be planted at a depth of from six to eight inches, and their bases should rest upon a liberal dose of silver sand. The most popular forms of lilies suitable for culture in gardens are given in the table on the next page.

The Chrysanthemum. The immense popularity to which the chrysanthemum as an exhibition flower has attained during recent years

has militated somewhat against its general employment as a garden plant.

THE MOST POPULAR LILIES

Name.	Height.	Colour of flower.
Auratum ..	About 6 ft.	White with yellow band
Bulbiferum ..	2 ft. to 3 ft.	Orange red, black spots
Madonna ...	tall, varies	White
Easter	2 ft.	White
Tiger	3 ft.	Red, purple spots
Speciosum rubrum	2 ft. to 3 ft.	White, pink spots, crimson markings
Orange	6 ft.	Orange, black spots
Scarlet Martagon	3 ft.	Bright red
Elegans ..	1 ft. to 2 ft.	Orange

It is a perfectly hardy flower, and, if it is not intended for exhibition, may be grown in the garden border with the same facility as the dahlia. Chrysanthemums are apt, certainly, to be damaged by rains and frosts in the late autumn, but they may be protected from this by an awning of some light material, such as waterproof calico. If grown in pots, they are generally transported at the first sign of frost into a cold greenhouse, and left to finish blooming there. This is the method attendant with least risk, and is generally adopted.

Chrysanthemums are divided into three classes: Incurved, Japanese, and Pompon. The incurved variety, as its name implies, has all the petals curving inward, and overlapping, so that it somewhat resembles a flattened ball in shape. In the Japanese variety of chrysanthemum the petals throw themselves about in every direction, so that the flower looks like the head of a mop, earning for it the colloquial name of "ragged chrysanthemum." The Pompon is a dwarf with small, closely petalled flowers, rarely more than two inches in diameter.

Growing Chrysanthemums for Cutting and Exhibition. The best soil in which to grow chrysanthemums is equal parts of loam, leaf mould, sand, and rotten manure. The young plants should be put in about March or April, according to the weather, about three feet apart every way. If they are simply to be grown for the purpose of cutting, there is no need to tamper with them again, except to give them an occasional dose of liquid manure, but if they are destined for show or decorative purposes in pots it is usual to remove many of the buds so that the whole strength of the plant can be concentrated upon two or three blooms, which will necessarily be of gigantic size. Chrysanthemums grown for this purpose, however, are usually cultivated in pots, beginning with a small thumb pot, and repotting each time into a larger size, until they are finally placed in nine-inch pots, which should contain the best loam, with a little finely powdered charcoal. It is necessary to tie chrysanthemums grown for large blooms to sticks, otherwise they will be topheavy, and fall over.

Like so many other flowers which the nurseryman has taken in hand, the chrysanthemum has innumerable varieties. A few of the best for general culture are Soleil d'Octobre (golden yellow), Madame Desgrange (white), Montague (purple crimson), Ryecroft Glory (yellow-shaded bronze), Vivian Morel (pale pink), Madame E. Roger (green). The last-mentioned variety is somewhat of a freak, and would be grown more as a curiosity than for any ornamental value; it is, however, very hardy, as it does well in many parts of London.

The "Buttonhole" Flower. If the carnation were grown for no other purpose, it would always be sure of a prominent place in gardens by reason of its value as a "buttonhole" flower. To be seen at its best in the open garden, however, it should be grown in beds or clumps. A good plan is to grow the bold, self-coloured sorts in beds, and have little clumps here and there, dotted about the borders, of picotees, flakes, and bizarres. These last three terms are the names by which the striped and marked varieties of carnation are known.

Layering Carnations. A rich, loamy soil is necessary for the carnation. This soil must be well drained, and just a little sand mixed with it. The richer the soil the more vigorous the carnation, but on a light soil the plant will never do well. The chief methods of propagation are from seed, and by the operation known as *layering* [24]. Layering is carried out in July or August, when the plant is in full vigour. Select a good strong shoot near the base of the plant, and clean off all the leaves on that shoot with a sharp knife, except half a dozen at the top. Cut half way through the shoot from below in an almost horizontal direction, for a distance of about 2 in., taking care to cut through a joint in the stem on the way. Push the wounded part of the shoot into the soil, which has been previously prepared by having sand mixed with it, and keep it in that position by pegging it down. Special pegs may be procured for this purpose, but a common hairpin answers the purpose almost as well.

Carnation seed must be sown in May, in pots or boxes of rich loamy soil. They must be stood in a sheltered spot, and, when the plants show a few leaves, they can be put out in beds of the same material, and left till late autumn. If they have the protection of a frame during winter, many of the young plants will bloom the following season.

Among the best carnations for the open garden are: White: George Macquay, Trojan [20], Alice; Pink: Duchess of York, Asphodel, Endymion, Raby Castle, Enchantress; Yellow: Miss Audrey Campbell; Buff: Mrs. Reynolds Hole, Prince of Orange. Scarlet: The Cadi, Isinglass, King Arthur; and Crimson and Dark Red: the old Clove Carnation, Uriah Pike, Mephisto, Boadicea.

The picotee and other fancy varieties of carnation are more numerous even in variety than the good self colours. Six good ones are Cardinal Wolsey, Ladas, Perseus, Dervish, Mrs. Robert Sydenham, and the Czar.

The Sweet Pea. There is probably no more popular annual flower in the garden than the sweet pea, and certainly none which yields a more bountiful supply of bloom for cutting. It may be had in practically every colour from white to what may, by a very slight stretch of imagination, be called a black, and is of the easiest culture. The sweet pea thrives in any ordinary garden soil, and may be sown either in autumn or spring. Seed should be put in the ground 2 in. or 3 in. apart, and at a similar depth. It is customary to attribute failure with sweet peas to the ravages of birds, and certainly they do a great deal of damage. This may be guarded against to a great extent, however, by rolling the seed in red lead before putting it into the ground. When the young plants show themselves, and are likely to be nipped off, the surface soil should be liberally dusted with soot.

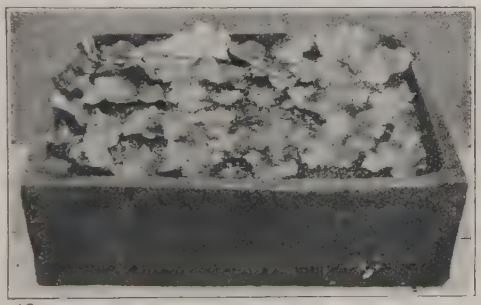
Sweet peas are usually seen in gardens trained up bean sticks placed against walls or fences, or in clumps. A method which has recently been put into practice with good effect, is to sow them in rows, a bean stick being driven firmly into the ground at each end of the row. At about 3 in. above the ground, a string is stretched from pole to pole, and the young plants lifted up, so that

their heads rest on the string. As they grow higher and need more support, other strings can be stretched across and so on, until they reach their full height. Practically, the only support to be seen is the pole at each end of the row, and even this may be hidden in a simple way by letting a fast-growing climber, such as the nasturtium, Japanese hop, or canary creeper, run up it. Unless it is desired to save seed of any particular plant for future use, the flowers should never be left on sweet peas until the seed pods form, as this weakens the supply of bloom. On the contrary, the blossoms should be cut almost before they are fully expanded, and then the plants will go on yielding a prolific supply of bloom right through the summer months. As regards sorts, all of those named "Eckford" are good, and there are several of these christened after different members of this famous grower's family. Apart from these, a few of the best are Blanche Burpee (white), Captain of the Blues, Venus (pink), Countess of Radnor (heliotrope), Cardinal (red), Primrose (pale yellow), Unwin, and Hemus.

17. A NEW BEDDING PANSY

The Bulbs of Spring. It is impossible to overestimate the value of bulbs in the garden, no matter whether they be the spring or autumn flowering kind. At present, the former are much more generally cultivated than the latter. This has been particularly the case during recent years, now that the custom of naturalising such things as daffodils, crocuses, snowdrops, and anemones, in the grass has arisen.

Hyacinths are usually grown in pots or glasses. For pot culture, a mixture of garden soil with sand and a little leaf-mould answers well, or the leaf-mould may be dispensed with if it is not readily available. October is the best month to plant the bulbs, and they should be barely covered with soil. A leading firm of growers says: "After potting, give one good watering, and then place the pots outdoors on a bed of ashes, cover with 6 in. of cocoa fibre, and leave them exposed to all weathers. When the bulbs have well rooted, and made about 1 in. of top growth, they may be removed indoors, first into a subdued light, until the foliage has attained its full green colour, and then in the sunniest situation at command in the greenhouse or conservatory. It is a good plan to place an inverted flower-pot over the young growths for a few days after being removed from the plunging bed, as by so doing they are protected from possible draught. Abundance of air, a moderately moist atmosphere, and plenty of water at the roots, are then necessary for early well-developed flower spikes."



18. PROPAGATING BEGONIAS FROM LEAVES IN A PAN

In quite small suburban houses, hyacinths in glasses are the rule rather than the exception. During the winter it is best to fill the glasses with rain-water to such an extent that the bottom of the bulb just touches the water. At first, keep the glasses in a dark place, filling them up with water as it evaporates; by this means, healthy root growth is promoted. By the time the glasses are nearly full of roots, they may be gradually exposed to the sun in a window. This treatment ensures large and healthy trusses of bloom. Hyacinths which have flowered in pots one year, will flower in a border for several years in succession afterwards, but the resulting flowers will not be so large.

The Narcissus (Daffodil). The daffodil [21] is undoubtedly the most valuable spring-flowering bulb we have in our gardens, and there is no capacity in which it cannot be used. It may be grown by thousands on banks, lawns, and in meadows, increasingly enormously, or it will flourish bravely on the sooty window-sill of a city slum. The best way to grow it in pots is to use three bulbs to a 5-in. pot. The soil it likes is ordinary garden soil, with a generous mixture of sharp sand. As daffodil bulbs vary so much in size a good general plan is to plant the bulb at one and a half times its own depth. After flowering, the bulbs should not be lifted out of the ground until the foliage has quite died down; but where this cannot be avoided, owing to the ground being required for other purposes, they should be carefully lifted, and re-planted in some spare corner until the foliage has quite withered, when they can be lifted and stored away until the autumn.

The narcissus family is divided into several important groups, including the Trumpet section, the Star daffodils, and the Poet's daffodils. They number several hundred varieties, ranging in price from a few shillings per hundred to twenty guineas a bulb.

The Brilliant Tulip. What the daffodil gives us in delicacy of colour the tulip supplies in brilliancy. It is not, however, adapted for culture in the grass, but does well in beds of soil as recommended for the daffodil. The genus is divided into three sections: Early flowering, May flowering (Gesneriana) and late flowering (Darwin). There is also a curious distinct breed called the Parrot Tulip, so named for its peculiar shape and colour. The tulip most suitable for town culture is Kaiser's Kroon, a brilliant scarlet tulip with yellow edges; while other good sorts, arranged in order of time of flowering, are: the Duc Van Thol group, Ophir d'Or, Proserpine, White Swan, Bouton d'Or, Gesneriana Spathulata, Golden Crown, Prince of Orange, May Queen, Salmon King, the Bride, and the Sultan, the latter approaching nearest to the much-sought-after black tulip.

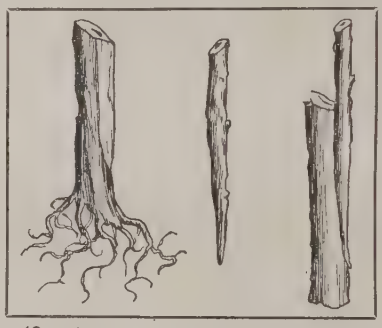
The Iris, Gladiolus, and Lesser Bulbs. Although different varieties of iris may be made to give flowers from the beginning of the year on into August, the great majority of them are spring flowering bulbs. These are what are known as the Spanish and English sections. September is the best month for planting the bulbs, which should be

put in deeply in any ordinary garden soil. There is a long list of sorts of all colours from white to nearly black, and splashed and marked with every conceivable hue. Some choice species of the iris include : Alata (Scorpion iris), Atropurpurea, Iberica, and Reticulata.

The spring flowering section of gladiolus bulbs is not a large one, only one or two varieties blooming as early as May. As, however, those which do not come into flower until June and July are planted at the same time as the ordinary spring flowering bulbs they are best included here. Gladioli require shelter from the wind, and also shade from the full heat of the sun. October is the best month to plant, though good results have been obtained with bulbs planted as late as Christmas. A layer of bracken or straw should be spread over them to protect them during the winter, while deep planting, say at a depth of six inches, also effects an insurance against damage by frost. The Bride (pure white) and Byzantinus (light crimson) are the best of this early flowering section.

Crocuses, snowdrops, anemones, scillas, alliums, dog's-tooth violets, chionodoxa, and muscari are the most important of the dwarfer growing spring flowering bulbs. Their culture is exceedingly simple. In fact they merely require putting in the garden or woodland, or wherever it is proposed to grow them, at any time during the months of October or November when the ground is dry. The rule of planting at the depth of a bulb and a half holds good in all cases.

Autumn Flowering Bulbs. Just as the spring flowering bulbs are planted in autumn, so should the autumn flowering bulbs be planted in spring. With the exception of the gladiolus, however, the culture of autumn flowering bulbs has been somewhat neglected, though their presence would be a great help at a time when gardeners are apt to rely very extensively upon the dahlia and chrysanthemum.



19. A METHOD OF GRAFTING ROSES

It is possible to get exactly the same effect with the crocus in autumn as it is in spring. Their culture is simplicity itself. They should be planted in any ordinary garden soil, and just covered with earth, or, if in pots as specimens, in ordinary potting mould. The best autumn flowering crocuses are the Asturicus varieties, which represent the mauves and purples in all shades ; Sativus, the purple saffron crocus ; Hadriaticus, pure white ; Zonatus, rose and orange ; and Speciosus, bright blue, recalling, when planted out in the grass, the beauties of the grape hyacinth in the spring.

The autumn flowering gladioli are varieties of the species known as Gandavensis, and they may be relied upon to provide those brilliant masses of scarlet so often needed but so rarely seen in the autumn garden. It is merely necessary to plant them out in March in good soil, and leave them to take care of themselves. They are somewhat shy of frost.

The belladonna lily (*Amaryllis belladonna*) is the most beautiful of all the autumn flowering bulbs, but it should only be planted on the south side of a house or wall, as it is not quite hardy in other situations. It grows nearly a yard high, with large lily-like white flowers, tinged with pink towards the centre. It needs deep, fairly rich soil, and if the bulbs are planted in autumn, which is the best time to ensure a display of bloom the following year, they should be protected with a layer of fibre during the winter. They soon establish themselves and will bloom freely every year.

The tiger flower (*tigridia*) should, as far as culture is concerned, be treated the same way as the gladiolus. The flowers are six inches wide, bright red in colour with crimson spots, and the plant attains to a height of 2 ft. or more. Each flower only lasts a day, it is true, but a succession of flowers lasting in all nearly two months are borne on the same stem.

Other autumn flowering bulbs include Crocosmas ; Sternbergias (the best authorities say that this is the lily mentioned in the Bible) ; Leucojum ; the autumn flowering Scilla.

The Dwarfer Flowers of the Garden. The proper place for dwarf flowers in the garden is obviously in front. Many of them are of great value for edgings, while others help to form a carpet at the foot of taller growing things.

Although the violet is frequently found wild in the hedgerows and copses of the country, the practice of cultivating it, either for private use or for market purposes, is not a general one. The French grower thinks nothing of having two or even three acres of ground covered with violets, while the English grower is content with a few square yards. As violets like shade, they are essentially suitable for carpet plants, and they thrive in any moderately good soil. It is well not to leave them for more than two years in the same spot, however, as they deteriorate in quality after that time. They are best planted in May for the following season's display, a little manure from the hotbed being forked in when planting. The most popular sorts are Neapolitan, Marie Louise, La France, the Tsar, and Princess of Wales. Belle de Chatenay is one of the best white sorts.

Pansies, Lily of the Valley, and Lobelia. The pansy [17] is a sister of the violet, as both belong to the same genus (Viola). It is one of the easiest garden flowers to grow, and may be used as an edging or to cover the surface of a bed of roses, or other flower. Pansies may be planted either in autumn or spring, the former for early flowering. They should be put in about 9 in. apart. To obtain plants from seed in the open air it should be sown in the middle of summer (say, July), and the little plants transferred to the flowering beds in the ordinary way in the autumn, when they will bloom the following spring. Both the violet and the pansy are subject to attacks from green fly, and, occasionally, red spider.

The lily of the valley is so frequently seen forced in pots in company with other exotics in florists' shops in the middle of winter that the fact that it is a perfectly hardy garden flower is apt to be overlooked. It can be grown almost anywhere, and suburbs near to the smoke of London appear to suit it well. The corms should be planted in October, just at the time when the spring flowering bulb planting is going on, and the bed in which it is proposed to plant them should have a liberal dose of leaf-mould mixed with the surface soil. The corms

should be placed about 3 in. apart, and just covered with soil, and they will start into growth in early spring. The lily of the valley is one of the best solutions to the ever-recurring problem of what to plant in the shady side of a town garden.

The dwarf section of the lobelia family is known technically as *Lobelia Erinus*. It is the familiar little blue flower so often seen as an edging plant in gardens, and also as a prominent feature in window-boxes, for both of which uses it is admirably adapted. The lobelia is only half-hardy, and requires the protection of a greenhouse in winter. The plants can be raised from seed sown in boxes of light soil at Christmas-time, or thereabouts, and given a gentle heat. If the common mistake of sowing the seed too thickly has not been made, they will be ready for putting out in May without further transplantation, and will continue to bloom until cut down by autumn frosts.

20. BORDER CARNATION (TROJAN)

Virginian Stock, and Other Dwarfs. The Virginian stock is one of the very hardiest of dwarf growing annual flowers, adapted for an edging, and its culture is simplicity itself. It is only necessary to go out into the garden on a bright day after the rain during April, and drag a stick along the edge of a bed or border, so that it leaves a furrow behind it. Into this furrow sprinkle the Virginian stock seed gently, and just cover it with the earth which has been disturbed. In a very few weeks a substantial edging, from 4 in. to 6 in. in height, will make its appearance, covered with thousands of tiny flowers — red, white, or mixed, according to the variety used. One sowing will bloom for weeks. Fresh rows should be sown at intervals an inch or two before or behind the original edging.

The most useful variety of the Alyssum family of dwarf-growing plants is the sweet alyssum, a white, fragrant little flower, useful as an edging, or charming in effect if sown to form a broad sheet, and flowering all through the summer and well on into the autumn. It is best sown in the open air in spring, and if the precaution of sowing thinly is taken there is no need for transplanting.

Nemophila is another of the dwarf hardy annuals, and should be treated in the manner already described for this class of flower, with one difference. In addition to sowing in the spring for summer flowering, a sowing should be made in the autumn, where tulips and other of the taller flowering spring bulbs are being planted. The nemophila will then bloom with them in the springtime as a carpet of delicate pale blue or white as the case may be. Nemophilas will flourish in any soil, and so are eminently adapted alike for culture in town or country. The plant should never be used, however, where cats are likely to cause any trouble. For some mysterious reason, cats are particularly fond of this plant, and have been known to travel a long way to get at a garden in which there was a bed of it. As their appreciation takes the form of lying down and rolling over and over in it this naturally means the destruction of everything in the bed.

The garden forget-me-not (*Myosotis dissitiflora*) is probably the most useful of all the dwarfer flowers of the garden, inasmuch as it blooms in spring, and so forms a carpet for the bulbs. Seed may be sown in the autumn at the same time, and in the same beds, as the spring-flowering bulbs are put in, and they will all come up and flower together. The plants are easily propagated by digging them up and dividing the roots during the flowering season, or if they are allowed to remain where they are the seed will ripen, drop off, and sow itself during the late summer months. This is not the forget-me-not of the stream side, about which poets write so much, the latter being known as *Myosotis palustris*.

Other dwarf flowers of spring are *Arabis alpina*, *Limnanthes Douglasi*, *Saponaria calabrica rosea*, and *Silene pendula*, while the stonecrops are at all times useful, apart from their place in the rock garden, in covering up odd corners. The flowers just mentioned are all hardy annuals, and merely require the treatment already set forth for such things.

21. "EMPEROR" DAFFODIL
For bed, pot, or window-box

Carpet Flower-beds. Upon few subjects has more wordy warfare been waged than that of carpet bedding. The extreme school of "wild gardeners" execrate it, and there is no doubt that, if carried out to excess, these flat beds made up into carpet-like designs are both dull and uninteresting. The rational gardener, however, will be quick to recognise that there is a place for them in every garden that has any pretensions to size. Carpet beds may be of any shape the designer has a fancy for, but the pattern is usually regulated by the size and shape of the place in which the bed is to be put. A very good plan is for the gardener to work out designs on paper, drawing them to scale, during the long winter evenings. A good idea of what the general effect will be like may be obtained by colouring these plans as near as possible to the hue of the plants it is intended to employ. Before proceeding to cut out the bed it is best to mark an outline of it in whitewash.

The majority of carpet-bedding plants are raised from seed, sown in boxes in March, and subjected to a bottom heat of about 80°. One of the most important plants for carpet bedding is the alternanthera, of which several varieties are useful. They range in colour from yellow to brownish-red, the variety aurea being a brilliant yellow. The pyrethrums, or golden feathers, are another mainstay of the carpet bedder, and the different varieties give him grey, pale green, and gold for his beds. Antennaria

is the plant generally employed to get the delicate silvery white effect so often seen in the best carpet beds, while for very deep red effects the beet is occasionally employed with advantage. The varieties of lobelia mentioned on the previous page are valuable aids to carpet-bedding. No carpet bed would be complete unless it contained some of those curious flat rosette-like plants called *Echeveria secunda*. They are raised from seeds sown on fine soil in gentle heat, and merely require protection from frost in winter.

Where a centrepiece is desired for a carpet bed, and such a thing is often an improvement, it is best to employ the fishbone thistle (*Chamæpeuce cassabonæ*), a graceful plant, with shining dark-green leaves marked with white and brown.

The following are in general use as carpet bedding plants, but they require no special treatment: *Alyssum maritimum*, *Mentha pulegium*, *Iresine lindeni*, and *Sedum glaucum*.

Summer and Autumn Bedding Plants. Among gardeners the term "summer bedding plants" is understood to comprise those plants which, although invaluable for giving us a display of bloom, say, from May until September, are too delicate to withstand the rigours of our winters, and need the protection of a frame or greenhouse, or at lest a shed, if they are to be kept alive. Until comparatively a few years ago, summer bedding was confined to the laying down of strips of blue lobelia, scarlet geraniums, and yellow calceolarias, which occurred in garden after garden with never varying monotony; but things have now happily altered for the better, and a wider range of effect is possible. In the genial climate of the south and west of England some of the plants described hereafter as needing protection during the winter may remain in the open ground all the year round with impunity, but this favoured area is of such small extent that for practical purposes it is necessary to treat summer bedding plants as being only half hardy. The flowers enumerated hereunder are those most generally in use for the purpose mentioned, and may be supplemented, where opportunity affords, by those mentioned in other sections.

The Geranium, Fuchsia, and Begonia. The geranium, as most people know it, is not a geranium at all, but a pelargonium; it originally sprang from the wild geranium, but has been crossed with various species in order to obtain fresh varieties. It is the most popular of all summer and autumn bedding plants, and one of the easiest to cultivate well. It will grow in any ordinary garden soil, and is increased by taking cuttings, or slips, when the flowering season is practically over—say, in September. These slips should be cut off the parent plant at a very acute angle with a sharp knife, and should be put into little pots containing some fairly good soil, and with a pinch of sand at the bottom of the hole where the cutting is stuck in. As soon as there is any fear of frost they should be got in under glass, and they will quickly root and be ready for planting out the following May. Cuttings may also be struck in the spring, in slight heat, and will be ready for planting out at practically the same time, but they will not make such sturdy plants. Very little water should be given during the winter.

Fuchsias thrive in soil similar to that suitable for geraniums. They are, however, propagated in a somewhat different manner. It is customary to take old plants which have been stored in a cellar or somewhere else away from frost during the winter, and start them into growth in the heated greenhouse. When the young shoots appear, and are about two or three inches in length, they should be taken off and potted up as directed for geraniums. They should be thoroughly hardened off by exposure to light and air before being planted out. In some gardens, especially near towns, the buds of the fuchsia have a provoking habit of dropping off instead of opening into flower. The general cause of this is insufficient water, or, if the fuchsias happen to be growing in pots instead of in beds, it will probably be found that they are "pot bound"—that is to say, the pot is not large enough to contain the roots. The most reliable fuchsia for town gardens is known as *Riccarboni*, which does well in London suburbs in the open.

The begonia of so much value for summer and autumn bedding is what is known as the tuberous-rooted begonia. It is best raised from seed or leaves sown in early spring in pans [18] or boxes in sandy soil and brought on in a temperature of not less than 60°. In three weeks or a month's time the plants will be ready to be put into pots, after which they should be gradually hardened off for planting out in June. Great care should be exercised in the sowing, as the seed is so very minute. In a rich, light soil begonias will continue to flower until cut down by frost. When this happens it is usual to lift them up, and store the tubers which will be found to have formed at the roots, in silver sand in a dry place. These tubers can be started into growth again in the spring. There are many sorts, in all shades of white, yellow, salmon, and red, and some double ones [30].

Dahlias, Calceolarias, and Other Bedding Plants. When the summer begins to wane there is probably no more important bedding plant in the garden than the dahlia, as it forms stout bushes three or four feet in height, giving a generous supply of bloom for cutting, right into the very late autumn. There are four principal kinds: the double dahlia, which is the old-fashioned almost spherical-shaped flower so often found in cottage gardens; the pom-pom, which is a smaller edition of the double dahlia; the cactus, distinguished by its almost claw-like petals; and the single dahlia. Dahlias are usually propagated from cuttings, which are obtained by starting a tuber into growth in a heated greenhouse in January or February, and taking off the cuttings as the young shoots appear. These are then treated in the manner described for seedling begonias. When the dahlias are thoroughly hardened off, and ready for planting out, a stick some four feet in height should be pushed into the ground at the side of the hole dug to receive each plant, and to this stick the young dahlia should be tied sufficiently tightly to prevent it being swayed about by the wind. After flowering, the bulbs should be lifted and stored in a box of soil in a frost-proof place during the winter.

The yellow calceolarias are a familiar sight in the summer bed. They are propagated by cuttings taken in the autumn in sandy soil, and placed in a cold frame, where they will root during the winter, and so be ready for planting out with the rest of the bedding stuff [22].

The canna is as effective in the summer garden for its foliage as for its flowers, most of the varieties having rich brown leaves. A group of cannas in the centre of a large bed is particularly effective, reaching, as the plant often does, to a height of six feet. They are propagated by spring cuttings, in the manner described for fuchsias, or by dividing the old roots, and potting them up. They need a sunny position, or they fail to develop. The best sorts are Antonin Crozy (crimson), Antoine Chantin (salmon colour), and Paul Bert (yellowish red).

The heliotrope is best known under its old-fashioned name of "cherry pie," and the little

A STATELY TENANT OF THE GARDEN

THE GLADIOLUS WHICH FLOURISHES IN SUNLIGHT

This photograph and that on page 5949 are by courtesy of Messrs. Sutton & Sons, Reading

flower is a great favourite because of its delicious perfume. It is propagated in the same way as the fuchsia, or forced from seed and hardened off. It is generally a failure in moist soil, and, when desired there, should be kept in the greenhouse.

Petunias and Tobacco Plants. The petunia is a hardy annual, raised from seed sown in heat in February, and planted out in May. Particular care must be taken in planting out, as the roots of the plants are very brittle, and liable to damage if they are at all carelessly handled. Seedling plants often yield bloom with very curious markings; and if it be desired to perpetuate these, cuttings should be taken in August, and placed in pots or a frame in soil which is well mixed with rotten manure and kept moist. They must be wintered in a cold frame, and care taken that the frost does not get at them. Good bedding sorts are Countess of Ellesmere (crimson with paler throat), Delicata (white with purple stripes), and Doctor Hogg (purple with white throat).

No garden is complete without its tobacco plants. They should be treated as half-hardy annuals, and raised from seed sown in heat in February, when they will be ready for planting out with the rest of the summer and autumn bedding stuff. The one most frequently met with is *Nicotiana affinis*, particularly sweet scented in the evening, and reaching a height of about two feet. A taller variety is called Sylvestris—three feet in height, the flowers of which do not shut when exposed to the full glare of the sun, as is the case with Affinis. A very interesting variety is called Sanderæ, having red flowers.

The Hardy Ferns. In order to grow hardy ferns to the best advantage, they must have a shady position in the garden. It is not, of course, impossible to grow ferns in the sun, but it is hopeless to expect them to do well there, as they soon get scorched up. Ferns dislike being moved; hence, to get the best results, the fernery should be established at some spot in the garden where it is likely to remain for a number of years. A sloping bank makes an ideal spot for a fernery; but, no matter where it may be, it is essential that the ground should be well drained. Ferns will not flourish when they have a lot of stagnant moisture about their roots, though, at the same time, the majority of them thrive admirably in the neighbourhood of a running brook or stream. The ideal soil for the fernery is a mixture of good loam and peat, the former predominating.

Ferns are usually propagated by taking the seeds, or spores, which are found upon the backs of the fronds, and spreading them carefully upon the surface of a lump of peat, keeping the peat thoroughly moist, when the majority of the seeds will successfully germinate. Those ferns which have running roots, however, may be divided in the usual manner. In order to ensure that fresh, bright green appearance so much to be desired in ferns, it is necessary that the foliage should have plenty of water. In small indoor ferneries this moisture is often supplied by the introduction of a small fountain. Out of doors the best substitute is frequent soaking with a hose the rose of which has holes of the smallest size.

There are several varieties of spleenwort (asplenium), ranging from one to two feet high respectively. The most important is the black spleenwort (*Adiantum nigrum*), which, in addition to being grown among other ferns, may be planted with success at the foot of such shrubs as azaleas to act as a carpet. Its fronds are also useful when bouquets have to be made up, or to mingle with cut flowers for general decorative purposes.

Royal and other Popular Ferns. The Royal fern (*Osmunda regalis*) is rightly named, as it is the largest and most imposing of all our native ferns. It has been known to attain a height of eight feet, though its average altitude is not so much as this. It wants damp, peaty soil, and may, in fact, be planted with its roots in water in a shady spot. There are several varieties, natives of North America, useful where large collections are being made, but otherwise not of great importance.

One of the most popular ferns is Hart's Tongue fern (*Scolopendrium vulgare*), deriving its name from the shape of the fronds. Like most other ferns, it likes shade and moisture, but has the notable characteristic of thriving particularly in a soil containing lime. It is attractive when grown in pots for decorative purposes.

The Lady fern (*Athyrium*) is another family of ferns much overladen with valueless varieties, but the type is worthy of cultivation under orthodox conditions in the fernery, or among evergreen herbaceous plants. It dies down during the winter, and therefore requires no water then.

A very useful, hardy little fern is Polypody (*Polypodium*), which may be grown on walls or in rockwork, the fronds of which are green all the year round. It is one of the easiest of ferns to propagate, being easily increased by dividing the roots—an operation best carried out in the spring time. It prefers a liberal admixture of sand in the soil in which it is grown.

The Shield ferns (*Aspidium* and *Polystichum*) are eminently suited for culture in town gardens, as they will thrive in a comparatively poor soil provided they have plenty of water during the hot months. The shield ferns are particularly useful for planting under trees, where there are often bare spots upon which grass refuses to grow. The well-known Holly fern is a variety of this family, of which over 100 members are found in catalogues.

There are several other families of ferns, individual members of which are worthy of a place in our gardens where a speciality is being made of the fernery. The system of nomenclature by which they are distinguished is a very confusing one. In any case, too many ferns in a garden are a mistake, and unless the place is of any considerable extent it is perhaps a mistake to lay down a fernery at all.

Tall Plants. When first laying out a garden, or altering the appearance of an existing one, the proper use of the taller plants is a matter which requires very careful consideration. In a small garden the employment of many tall plants is a mistake, for not only do they overshadow the humbler plants growing at their feet, but their general effect is to make the garden appear smaller than it really is. In fact, the only positions in which tall-growing flowers can be employed with advantage in small gardens are in the borders against a wall or fence. Even then, if there are many of them, they give the place a somewhat military appearance, unless, as often happens in poor soils, their weak stems fall untidily sideways.

In large gardens the tall flowers can be used in profusion almost everywhere, to break up the monotony which would otherwise be produced by the dead level of height of about 2 ft., which is attained by so many of our fairest garden flowers. They may be used in clumps in borders, or in the centres of large beds, or they look particularly

charming in beds by themselves set in the middle of an expanse of turf, so that they can be admired at a little distance.

Hollyhock and Larkspur. The hollyhock is one of the most useful of the tall-growing flowers, and, although it is sometimes called old-fashioned, it is without a rival for effectiveness in poor soils. It is no uncommon thing to find these plants self-sown in gardens, but such varieties are best relegated to the wild garden. The choicer sorts, however, deserve to be cultivated everywhere. There are two ways of growing hollyhocks. One is to sow seed in autumn in a cold frame, protecting it during the winter and putting the little plants out in spring, and the other is to sow in February in heat, and plant out in spring or early summer with the bedding stuff. The former method usually gives sturdier plants. The average height of the hollyhock is about 6 ft. or 7 ft., though there are many instances on record where they have attained an altitude of nearly 20 ft. Nurserymen keep a good many sorts, varying in colour from white to a very dark crimson, which is almost black, and including yellow. There are also double-flowered sorts, all of which are worth growing where there is sufficient space.

The Garden Foxglove. To the novice who knows the foxglove only as a tall, pale purple plant of our lanes and hedgerows, and is apt to regard it as almost a weed, the idea of growing it in a garden may seem peculiar. As is the case with many other flowers, however, it has been taken in hand by nurserymen, who have raised many new and valuable sorts. Foxgloves require a good deal of space, however, and for that reason must be introduced into a small garden with care, as they soon develop a habit of sowing themselves. Hence, under such circumstances, they are best used as specimen plants in large beds. The method of culture is similar to that already given for the delphinium, and the white variety is the most imposing, often attaining a height of 6 ft. Canariensis, with flowers of a brown colour, and grandiflora, having yellow blooms, are two interesting sorts if variety is desired, while there are several sorts with spotted flowers known as gloxinia-flowered foxgloves, which are interesting.

Lupins. It is the perennial lupin which is the tall-growing variety of lupins. The culture of lupins is simplicity itself, as the seed simply needs to be sown in any garden soil in spring, and the plants thinned out when they are a few inches in height. The thinning should be drastic, for

22. CALCEOLARIA

The tall-growing larkspur (Delphinium) must not be confounded with the ordinary larkspur of the garden. Though both belong to the same family, the tall larkspur is a perennial [29], while the ordinary larkspur is an annual, and must be sown afresh every season. The perennial larkspurs can be raised from seed, either by sowing in heat in the early spring and planting out the seedlings where they are to flower, or by sowing in the open ground in the summer, in which event good, strong plants will be obtained to bloom the following year. Though the larkspurs do best in loam, they may be made to thrive in a light, sandy soil, provided it is well manured and freely watered.

The many new hybrids embrace all sorts of colours from pale yellow to purple and red, but the rich blue sorts are, perhaps, of the greatest value for general garden purposes. Their average height is about 5 ft., though some of the newer hybrids are much taller. As these larkspurs increase rapidly, they should be dug up and the roots divided every four or five years. When once they have started flowering, they can be made to continue to do so for several months by cutting off a flower spike as soon as it has done blooming, when another one will immediately begin to make its appearance from the root of the plant.

the lupin is of bushy habit as growth proceeds. Though, strictly speaking, perennials, lupins frequently fail after three or four years, but they are so easily grown from seed that this is not a matter of great importance. The best sort, especially in a poor soil or a rocky corner, is the tree lupin (*Lupinus arboreus*), a stout, bushy plant with stiff spikes of yellow flowers, reaching to a height of 4 ft. or more. *Lupinus polyphyllus* is an even taller sort, with purple-blue flowers, and of this species there is a white variety—Albus. All the tree lupins are excellent plants to employ in large places where the formal garden melts away into the woodland, and the soil is probably not so rich or constantly worked as it is nearer to the house.

Flame Flower or Torch Lily. This is a valuable plant of many names. It boasts two Latin ones—*Kniphofia* and also *Tritoma*—while it is also known in different parts of the country as the torch lily, and sometimes as the red-hot-poker plant. It is a hardy perennial, cultivated in the same way as the delphinium, and at its best in a deep, rich soil, though it will thrive in practically every garden. When it is desired to increase the plants, they should be taken up and the roots divided, either in spring or autumn. The most popular variety of the flame flower is *Kniphofia aloides*, attaining a height of 6 ft. or more, and

having long flowering spikes of particularly brilliant scarlet flowers, shading to orange. It is the peculiar brilliance of the flower's spikes which has earned for it the name of red-hot-poker plant. An excellent plan to adopt with it, though it is rarely put into practice, is to mass it near the edge of a lake, in company with bamboos and pampas grass, where it gives a charming effect in summer and autumn.

The Despised Sunflower. Although many people pretend to despise the sunflower (Helianthus) [25], to do so practically amounts to a profession of ignorance regarding the plant. Certainly the ordinary annual sunflower, frequently met with in suburban cottage gardens, is not a plant which it is desirable to employ extensively, as it takes a lot of nourishment out of the soil. Several of the varieties of perennial sunflowers, however, are among the most valuable of the taller flowers of the garden, as the brown-centred yellow blossoms give a blaze of colour equalled by few other flowers of this class. The flowers are not particularly large, being in most of the varieties about 3 in. in diameter, but they are borne in great profusion. Their best use is, perhaps, singly, in beds, as they are of bushy habit, and, consequently, take up a good deal of room, though where there is a large shrubbery they may be massed with good effect. They are raised from seed in the same way as delphiniums, and may be sown in the open air early in April, where they are to flower. It is well to dig them up and part them every three years, as they increase very rapidly, and are apt to get out of hand if left undisturbed for a period longer than this. The best sorts are: Giganteus (10 ft.); Orgyalis (8 ft.); Decapetalus (6 ft.).

23. DUTCH PEARL AZALEA
For the greenhouse

Other Tall Flowers. Though most of the hibiscuses are generally considered to be greenhouse flowers, there are several of them suitable for open-air culture in favoured spots, particularly in the gardens in the south and west of England, and where deep and rich soil is available. In such circumstances, the best way to grow them is to treat them as half-hardy annuals, sowing the seed under heat in February, and planting out in the late spring. The variety most likely to succeed is *Hibiscus manihot*, which sometimes reaches a height of 5 ft. or more, and has yellow flowers, with a dark crimson centre. Another hardy hibiscus, which is often classed as a shrub, is Syriacus (the Rose of Sharon), reaching to a height of 8 ft. or 9 ft. under favourable circumstances. It makes a good centrepiece for a bed on a lawn, but should be used sparingly. There are hybrids with flowers of all colours from white to crimson.

Humea elegans is a half-hardy biennial plant—that is to say, seed must be sown one year for it to bloom the next, after which it dies. The seed should be sown after the middle of the summer in pots of rich soil, and given an occasional dose of liquid manure during the winter, as only by feeding them liberally can the best results be obtained. About a year after sowing they will be ready to plant out, and they may be used either at the back of the border, as a specimen on the lawn, or as centrepieces to a bed. They range from 5 ft. to 8 ft. in height, according to the soil and position in which they are grown, and have long feathery-like spikes of red-brown flowers.

In addition to the foregoing, many beautiful flowering shrubs may, with advantage, be introduced into bed and borders, instead of confining them to the shrubbery. Such introductions should be made with care, as if they are planted in profusion the tenderer plants will soon be starved to death. Shrubs which are suitable for such a purpose include the hydrangea, pæony, *Daphne mezereum*, some of the choicer rhododendrons, magnolias, flowering currants, spireas, and the mock orange.

How to Manage a Glasshouse. Glasshouses are roughly divided into three sections—the cool house, the intermediate house, and the hot house. In the cool house, no artificial heat of any sort is employed. The intermediate house, which may, perhaps, be more readily recognised by its popular name of "heated greenhouse," is one in which the winter temperature is always kept at least 15° above freezing point, and the hothouse, or stove, where most of the exotics are grown, should always be held up to a minimum of 10° above this. All houses require the same sort of treatment in their general management.

Hot water is the universal system by which houses are heated, and soft water, if it can be procured, is the best to employ, hard water quickly fouling the pipes. With the ordinary upright boilers, coke is practically as good as coal for stoking purposes, and has, at the same time, the merit of being more economical. It will burn longer, however, and maintain a regular heat better, if it is first slightly damped and mixed with coal dust. This latter is the best method to employ when making up the fires to last all through the night, as, if once the temperature of the house is allowed to fall below the minimum point at which it ought to be maintained, fatal results may follow. Every greenhouse should be furnished with a maximum and minimum thermometer, the tube of which contains tiny glass indexes, one of which indicates in the morning the lowest point to which the temperature has fallen during the night, while the other shows the highest point touched.

24. LAYERING CARNATIONS

Although the purpose of greenhouses is avowedly to grow tender plants, it must not be forgotten that the more a greenhouse is ventilated, the healthier will be the condition of its occupants, provided the atmospheric conditions are right. On dull, wet, or foggy days, but little air can be given, but when the

weather is bright and warm, the ventilators can be kept open all day long, provided the right temperature is maintained. Cleanliness is an essential feature in the management of a greenhouse. Before any potting is done, the pots should be scrubbed perfectly clean, and this cleanliness should be maintained after they are filled by washing them over outside at intervals of a week or two. The shelves of the greenhouse should be washed down at least once every three weeks, and the glass itself, as well. This operation affords opportunity for looking over the plants. Such a house cleaning, if it may be so termed, not only benefits the plants themselves, and improves the appearance of the house, but it also helps to keep away insect pests.

Never use cold water in a hothouse when watering plants. It should always be a few degrees higher in temperature than the atmosphere in the house. The best time to water plants is about the middle of the day in winter and the evening in the summer-time. In the spring and autumn, watering may be done early in the morning. Greenhouses in very sunny positions will require to be shaded in the summer-time from the glare of the sun in the middle of the day. This shading usually takes the form of a blind which can be pulled down over the roof and let up again when necessary. Five or six hours in the middle of the day is generally long enough for this shading to remain down, provided the sun does not go in, in which case it should be pulled up immediately. In the place of these blinds, or shades, a mixture of whitening and water is sometimes thrown over the sunny side of a house, but this rough and ready method of shading has two drawbacks—it whitens everything with which it comes in contact, and cannot, moreover, be removed instantaneously during a cloudy time.

25. DWARF SUNFLOWER
(*Helianthus multiflorus*)

The Flowers of the Greenhouse The proper arrangement of the greenhouse is one of the gardener's most difficult duties, especially if the space under glass at his disposal be limited.

Where there are two greenhouses only, it is certainly better to devote the larger one entirely to show, and keep the smaller one for rearing seeds and cuttings—that is, assuming that one is a warm and the other a cool greenhouse. The ideal way is, of course, to have houses of three different temperatures in duplicate, one for show and the other for use, looking at it from the gardener's point of view. So much depends, however, upon the likes and dislikes of an employer that no definite rules upon the subject can be laid down.

For the purposes of this article, the word "greenhouse" is intended to mean the general purpose, or intermediate house, the temperature of which is not allowed to drop below 40 deg. in the winter. Practically all the summer and autumn bedding plants mentioned on page 5946 may be flowered in the greenhouse, and bloom had several weeks earlier than if they are planted out in the open ground. Daffodils, tulips, lilies of the valley, and all the other spring-flowering bulbs may readily be forced on in boxes for cutting or table decoration.

The Most Important Greenhouse Plants. The abutilons are a family of fairly large sized shrubs requiring a good deal of room, and therefore out of place in a small greenhouse. They are raised from seed sown in early spring, or from cuttings of old plants taken at the same time. As soon as the plants are big enough to handle they must be repotted into larger pots, and the process repeated at intervals until the plants are full grown; in this state they often attain a height of 6 ft. The best sorts, especially for commercial purposes, are Boule de Neige (white), Royal Scarlet (red), and Golden Fleece (yellow).

Acacia. The acacia is better known by the name of mimosa, and is best raised from seed sown in spring in the ordinary way, as attempts to propagate it from cuttings are rarely successful. There are several sorts, all very much alike, but the best for general purposes is *Acacia dealbata* where space is of no object. It is this variety which is sold in such huge quantities in the streets of towns and cities. A lot of it comes to London from the South of France, but English grown mimosa usually realises an average price of 4s. per "pad." All the acacias flower in spring time, except Platyptera, which is an autumn-flowering variety.

Azalea. The azalea in the greenhouse is now usually grown in the form of the small pot plant, so familiar in the florists' windows. Although a hard wooded plant, its culture is very similar to that of the camellia, except that it should be grown in pots instead of tubs. It flowers during the early spring, and should be stood out about June, giving plenty of water so that the wood can ripen properly. In the south and west of England some sorts grow into bushes in the open. *Azalea mollis*, Indica, Fielder's White, and Dutch Pearl [23] are the most useful sorts. Good market plants, the bulk of which come from Ghent, fetch normally from 24s. to 30s. per dozen.

Begonias are among the most valuable winter-flowering plants of the greenhouse, while there are in addition some sorts equally desirable on account of their brilliantly marked foliage. They are not at present seen to a great extent in private greenhouses, but they are largely grown for the market. They are best propagated by cuttings taken in the spring, and potted up in tiny "thumb" pots, in loamy soil, with a good layer of silver sand on the top of it. If allowed to have a warm corner in the greenhouse for the first month or two they will make rapid growth, and when the pot is full of roots the plant should be shifted into a 5-in. pot, where it will flower the following winter. The best sorts are Gloire de Lorraine, President Carnot, Winter Cheer, Metallica, and Semperflorens, while of the fine foliage sorts the varieties of Begonia Rex are mostly sought after.

Calceolaria and Camellia. The shrubby section of calceolaria used for bedding out has already been dealt with, but the herbaceous varieties are equally important, as they include many choice new hybrids for specimen and exhibition purposes. They must be sown one summer to bloom the next, in very finely powdered loam and sand, moistening the soil first and sprinkling the seed very finely over the surface. The box, or pan, in which the seed is sown must then be covered with a sheet of glass, and put in a moist corner of the house. As soon as the plants are large enough to he handled they must be transferred to "thumb" pots, and afterwards to those of larger size, in which they are to bloom. As herbaceous calceolarias like moist and shade care should be taken to shield them from the direct rays of the sun. Practically every nurseryman of any note has his own choice list of hybrid calceolarias, of all sorts of colours and markings.

By far the best way to grow the camellia is in a tub. Although essentially a greenhouse plant, it can be moved out of doors the summer after it has done flowering, and its home in the greenhouse occupied for a few months by something else. The best time of the year to start camellia culture is in August, when the plants should be repotted, in a mixture of loam with a little peat. In the case of the camellia, repotting does not necessarily mean putting into a larger pot, for it is one of those things which seem to do best without too much root room. The plants should be brought indoors in October, and given an occasional weak dose of liquid manure, and they will flower from the end of November onwards. The well-known white camellia is called Alba Pleno, and is the easiest of all to grow. The best pinks are Lady Hume's Blush and Beauty of Waltham; of the reds, C. M. Hovey and Donckelaari. Although there is a huge demand for market camellias it is not a very paying branch of horticulture, as the prices run low. From 1s. to 1s. 6d. per box of two dozen blooms is the average price.

26. STEPHANOTIS
The sweetest-scented flower of the greenhouse

Cinerarias. These are decorative plants of many hues and colours, and are best raised from seed every year. This seed may be started in a cool frame in light, sandy soil in the month of May, and the seedlings transferred to "thumb" pots as soon as they are large enough to handle, repotting them once more as required. As soon as the first sign of frost makes its appearance they must be transferred to the greenhouse, but not the hottest part, as they are satisfied with quite a moderate temperature. They will bloom from Christmas until quite late in the spring. There is generally a good demand for them at Covent Garden during the winter months, their chief use apparently being to stand on the dining-tables of hotels, a purpose for which they are well adapted, as they last in bloom a long time.

Hardy Greenhouse Flowers. In the south and west of England, the hydrangea is hardy, but it is generally grown as a greenhouse plant. In its popular form, and the one in which it is always seen on the market, it is a one-stem plant with a big head of bloom. These plants are obtained by taking the stout shoots of old plants and treating them as cuttings, in any ordinary potting soil, when they strike readily and make rapid growth. The natural colour of the flowers is pink, but they may be induced to show blue blossoms by soaking the soil with alum water, or growing them in soil in which there is naturally a good deal of iron. Limited market demand at 10s. to 15s. per dozen.

The heaths are best grown in a mixture of peat and silver sand. They are useful for table decoration in winter, and are not difficult of culture if kept liberally watered and well drained. The most popular sorts for greenhouse culture are Gracilis, Hyemalis, and Ventricosa. There is a constant market demand for them, as, in the hands of an amateur, they usually bloom to die, and, in the winter plants in 5-in. pots may realise anything from 9s. to 20s. per dozen. There are over 500 sorts, mostly differing but slightly.

Primulas, Carnations and Chrysanthemums. The seed of the hybrid Chinese primulas should be sown in June in well sifted soil composed of loam and leaf mould, and treated in the manner described for calceolaria, taking care to keep them in the dark until the seed germinates. Their final potting should be into a 5-in. pot, and they will bloom from November until spring. The flowers are all shades of white, red, blue, magenta, and pink. A branch of the family much grown is *Primula obconica*, but it should never be handled except with gloves, as it is prone to set up an irritating skin disease.

Hardy flowers cultivated in the greenhouse include the carnation and chrysanthemum. Their culture is practically the same as that recommended for out of doors. The species of carnation for greenhouse culture is known as the tree carnation. It may be had in flower in either autumn, winter, or spring, according to the time the cuttings are taken, hence it is easy to arrange for a succession of bloom. Cut flowers of winter carnations fetch anything from 1s. to 2s. 6d. per dozen. For market purposes, chrysanthemums realise 3s. to 4s. per dozen bunches, of about two dozen blooms each, but the large specimen chrysanthemums are marketed at anything from 2s. to 5s. per dozen blooms.

The Ferns of the Greenhouse. Most of the maidenhair ferns thrive well in greenhouse temperature, especially the popular variety *Adiantum cuneatum*. Large quantities of maidenhair ferns are grown for market purposes, chiefly by division in spring, or from spores, but they need special houses for their culture if they are to be profitable; this particularly applies to the small maidenhair ferns which are frequently to be seen hawked about the streets in "thumb" pots, and for which the market price is about 1s. per dozen.

The peculiarity of the hare's-foot fern (Davallia) is the curious, brown creeping stems which lie on the surface of the soil, and give rise to the popular

name. The ferns are well suited for a small greenhouse rockery, as they are shallow rooting things, and may be well grown in peat and moss. One of the varieties, Mariesi, comes into this country in large quantities from Japan, rolled up in the form of balls, and twisted on wire into the shape of frogs, monkeys, and other devices. These are the well-known "Japanese fern balls," and, given gentle heat and plenty of moisture, soon cover themselves with green shoots. They are interesting curiosities, but are of little horticultural value.

The following ferns are also well adapted for greenhouse culture: *Asplenium bulbiferum, Lastrea patens, Nephrodium molle, Polypodium aureum, Pteris argyraea,* and *P. tremula.* The same methods may be applied to almost every fern that requires the aid of artificial heat to bring it to perfection. A general mixture of loam, leaf mould, and sand should be employed, and the mixture carefully gone over to see that it is not lumpy.

Repotting young ferns, or the separation of the roots of old ones, should be done towards the latter end of March, care being taken that at no time are they subjected to the full rays of the sun. Moisture should be given in plenty, but the pots or brackets in which the ferns are grown should be provided with sufficient drainage to allow the water to clear away easily, as stagnant moisture at the roots is fatal to them. The majority of ferns may be propagated from the spores, found on the under side of the leaves. When these cases begin to burst the frond should be cut off and carefully wrapped away in clean paper. In the course of a few days, the remainder of the spore cases will have burst, and a very fine dust will have come out of them. This dust should be carefully spread very thinly on the top of a shallow pan or box, containing plenty of drainage and a mixture of loam, sand, and a little peat. The pan should be gently moistened and covered with a sheet of glass, and, in the course of six weeks or so, if the moistening has been regularly attended to, what appears to be a covering of young green moss will show itself on the surface of the soil. This moss is simply a huge collection of tiny ferns, which may be pricked off as soon as they can be handled into other boxes or small pots to develop.

27. LADIES' SLIPPER
Cypripedium

The Care of the Hothouse. The hothouse, which is also known as the "stove," is used for preserving and growing all the choicest exotics which come to us from the tropics. Though the maintenance of a row of tropical houses is an essential feature of large establishments it is often overdone in gardens of moderate size, for, with the exception of the orchids, the flowers of the "stove" are not of great importance so far as their beauty is concerned.

The remarks on the care of a greenhouse given above apply equally to the hothouse, except so far as temperature is concerned. The hothouse should never be allowed to fall below 60° in the winter, and though much less heat than is usually thought necessary will be required in the summer, the thermometer should never fall below 70° at this period. Most exotics are moisture loving plants, and the use of hot-water pipes has a tendency to dry the atmosphere. Moisture must, therefore, be artificially supplied, either by fitting shallow troughs filled with water over the pipes, or else by liberally syringing the floor and wooden stages with water at frequent intervals.

Popular Inhabitants of the Hothouse. The Amazon lily (Eucharis) is a beautiful white lily-like flower, the plants bearing it attaining a height of about 18 in. The flowers are deliciously fragrant, and, as there is always a huge demand for them for bouquets and wreaths, they are well worth growing for market purposes, especially as they can be made to flower practically all the year round. They are grown from bulbs, which should be potted up in a mixture of loam and leaf mould, one bulb to a 5-in. pot. As they will not bear repotting frequently, the nourishment which they would have found in fresh soil must be applied by doses of liquid manure. Under this treatment they will yield two or three crops a year, and the average price of the flowers is about 3s. a dozen.

Though not grown to any large extent in private places, there is an enormous demand for gardenias as cut blooms, both for cheap buttonholes, and also for funeral wreaths. The gardenia is a small bush about 18 in. in height having very deep glossy green leaves, and white flowers with rather a sickly perfume. If potted up in the ordinary mixture of loam and leaf mould with a little red sand, and given plenty of heat and moisture during spring and early summer, they will flower freely through autumn and winter, or they may be had at practically any time by checking the growth. Cuttings stuck into sandy soil in spring root freely, and soon bear flowers, and this is the method generally adopted by market growers. The average price of the cut blooms is 1s. a dozen.

28. CATTLEYAS

Stephanotis [26] is the most widely grown of all the climbing plants in the hothouse. It has white waxy-like flowers of great fragrance, and is best grown in pots plunged into the border, or on a staging, as, if the roots are allowed too much room, the plants run to leaf instead of flower. The ordinary potting mixture suits it admirably, and it is increased from cuttings in the spring.

Ferns in the Hothouse. To avoid repetition, the reader is referred to the ferns of the greenhouse which have been dealt with above for details of culture, these details being equally applicable to the hothouse, the great difference between greenhouse and hothouse ferns being the natural one of temperature. It is more important than ever, however, that in the hothouse the ferns should be well shaded and kept moist—accidental exposure to bright sunshine, especially if the atmosphere happens to be a little dry, will wither them up and kill them

almost immediately. The following ferns are most useful for stove cultivation, and, as they have no English names, it is necessary to set forth their Latin ones in order that the plants may be readily procurable: *Adiantum caudatum, A. farleyense, Asplenium formosum, A. longissimum, Blechnum brasiliense, Davallia elegans, Gymnogramma calomelanos, Polypodium diversifolium, O. pectinatum,* and *Pteris tricolor.*

Orchids. There is no branch of gardening which has been made more bewildering, and more difficult to understand for the young horticulturist, than orchid growing. This is in a great measure due to the fact that new hybrids, the differences in which are indistinguishable even to experts, are being introduced every day. It is appalling to think that at the present time there are over 4500 varieties of orchids, many boasting Latin names of six words in length, ranging from the Odontoglossum for which 1150 guineas was paid in London in March, 1906, down to *Cœlogyne cristata* procurable for a shilling or two. A general knowledge of the requirements of the varieties of the great families of orchids is, however, all that the young gardener can reasonably be expected to possess.

When orchids first arrive in this country from abroad they are naturally in a very dry, shrivelled condition, and can have no better treatment than that recommended by Mr. W. H. White, F.R.H.S., in his excellent work, "The Book of Orchids." "The plants should, within a few days after their arrival, be suspended head downwards in an intermediate temperature in a shady part of the house, and be slightly syringed at least once a day. In a very short time the leaves will have assumed their natural colour, and the stems and old root stumps will commence to emit their new succulent roots. Immediately this is observed the plants should be taken down and placed in as small pots as possible, using the crocks for potting, so as to come up almost to the edge of the pot, covering the whole with good living sphagnum moss, and pressing it down moderately firm."

29. PERENNIAL DELPHINIUMS

The Most Important Genera of Orchids. The Calanthes are winter flowering orchids, the different varieties of which will give a succession of bloom for at least three months. They are grown in pots, half filled with drainage, this being covered with a piece of turf, grass downwards, and the pot filled with loam, sphagnum moss, and silver sand. A little water should be given to the bulbs until the foliage begins to make its appearance, but as the plant grows the quantity should be increased until a copious supply is found needful. This quantity should be gradually decreased as the foliage dies down and the flowers make their appearance.

After flowering the plants should be given rest for a month or two, and the bulbs repotted again in the spring. Some of the Calanthes do not lose their foliage in winter.

Among the largest flowered orchids are Cattleyas [28], purple in one of its many shades being the predominating colour. Many of them will thrive in the coolest part of the hothouse, and they can be grown by planting the pseudo-bulbs in pots, half filled with drainage as recommended for the Calanthe and the remainder a mixture of leaf mould or peat and moss. In their youngest stages they like shade, but as they progress they should be brought into full light and air. After blooming they should be given very little water during the time they are resting. Very closely allied to the Cattleyas are the Lælias, the culture of which is similar in every way, and there are many hybrids between the two families, known as Lælio-Cattleyas. There is a good market demand for Cattleyas. This demand fluctuates a good deal, and the prices change also, but six shillings a dozen blooms is quite an ordinary figure—they sometimes fetch double that price.

One of the easiest grown orchids is Cœlogyne, a variety of which, Cristata, with pure white flowers, is the most useful orchid that can be grown in a small house, or where space is limited, as the flowers are borne so abundantly. The orthodox orchid potting mixture of peat and moss suits the Cœlogynes admirably, and the practice recommended for the Calanthes, of gradually increasing the quantity of water as the plant grows, and decreasing it afterwards, should be carried out.

Cypripediums are more familiarly known as "The Lady's Slipper Orchids" [27], on account of the peculiar pouch which is a prominent feature of the flowers. They are a popular buttonhole flower, and there is hardly a month of the year when one or other of the varieties cannot be had in flower. The mixture of soil already recommended suits them, and they like one of the hottest corners in the house, protection from the direct rays of the sun, and plenty of water all the year round. Care must be taken with the drainage of the pots, however, in order that the water does not remain stagnant about the roots of the orchid, for this is fatal. They usually fetch about 3s. or 4s. per dozen blooms in the market.

Although the Odontoglossum numbers among its varieties the most expensive kinds, there are plenty of others quite within the reach of the very smallest grower of orchids. They may be given the coolest corner of the house; in fact, some of them—notably Crispum and its varieties—will flower in the greenhouse.

An orchid family most remarkable for its long sprays of flowers, which, in the majority of cases, hang downwards, in graceful showers, is Oncidium. Oncidiums will grow almost as readily in ordinary well-decayed leaf mould as in the orchid mixture.

Members of the following families of orchids are the others most generally met with in large collections, and the broad rules of culture laid down will be found sufficient in most instances: Cymbidium, Lycaste, Masdevallia, Maxillaria, Miltonia, Phalænopsis, Stanhopea, and Vanda.

The Cost and Economy of the Small Garden. Whether a garden be large or small, its economical management depends so much on soil, situation, and other circumstances that no hard and fast rule can be laid down to apply equally in all cases. Particularly does this apply to suburban gardens. There are some, notably in the western suburbs of London, attached to houses built on the site of market gardens, the soil in which is naturally good, and where but little in the way of manure is needed every year.

The initial cost of forming such a small garden, too, depends greatly on the condition in which the builder of the house has left it, or, if the house is not a new one, on the horticultural tastes of the previous tenant. Assuming that the ground is not in a very rough state, the following figures will serve as a guide to the initial outlay necessary :

	£	s.	d.
Jobbing gardener, two days weeding, digging, and preparing ground, at 5s. per day	0	10	0
Spade, rake, etc.	0	8	0
Lawn mower	0	14	6
Loam, leaf-mould, potting soil, for improving ..	0	12	6
Manure	0	6	0
Small collection of vegetable seeds	0	2	6
Small collection of bulbs	0	5	0
Small collection of hardy annuals and perennials	0	5	0
Fruit and rose trees and shrubs (say)	1	0	0
	£4	3	6

This figure does not, of course, represent the annual expense, which may in subsequent years be limited to practically the 12s. 6d. comprising the seed and bulb items, as fruit and rose trees rarely require renewing. The item for manure, too, is one which need not recur often, though, in towns, chemical fertilisers must often take the place of horse-manure, which is now difficult to procure.

A greenhouse, with its accompanying heating apparatus, and a frame, constitute a serious item. An efficient greenhouse for a small garden would be one (say, 9 ft. by 6 ft.) costing about £4, and the necessary heating apparatus another £3. A handy sized frame, 8 ft. by 6 ft., costs £2 15s. The prices given are those for the simplest form of house and frame and may be taken as being the lowest at which an effective greenhouse can be established.

Economy in Vegetables and Fruit. The most economical thing that can be grown in any small garden is undoubtedly the scarlet-runner bean. A shillingsworth of these, sown at intervals of a fortnight throughout the spring, will yield sufficient for the needs of a small family during the summer and on into the autumn—that is, assuming that they take their turn with other vegetables. Radishes, lettuce, and mustard-and-cress are most economical vegetables for town-garden culture. Pears thrive in town gardens much more readily than apples, while crops of cherries and plums are usually spoiled by the attacks of birds. Of the bush fruits, the gooseberry is most likely to yield a profitable crop under such conditions.

30. THE BEGONIA

Economy in the flower garden is to be effected by its help in furnishing flowers for indoor decoration and for "buttonhole" purposes. In planting a small garden for economy, it is not at all necessary to put the things in formal rows, as if planting for market purposes. Those flowers which yield large supplies of bloom for cutting purposes should be interspersed with such things as geraniums, calceolaria, lobelia, and the like, which, though not so adapted for filling vases, lend bright colour to the garden generally. Hence, when occasion arises to cut the flowers in the garden with a free hand, the presence of the things just mentioned will conceal the bareness which their absence would only serve to accentuate.

Economical Management of a Large Garden. The economical management of a garden depends almost entirely on the selection of a head gardener, and in this connection it often happens that the best horticulturist is not the man most suited to control a staff economically, and get the maximum amount of produce out of the ground at the minimum expenditure of money.

A young gardener who hopes to rise as high as possible in his profession should be careful not to lose sight of the commercial side of it. The days when an owner of a country seat simply gave orders for a garden beautiful, without counting the cost, are over. Certainly, owners of gardens take much more interest in them than hitherto; and the head gardener who can make the biggest show of bloom at the cheapest rate is the man who will get on.

Economy in labour is one of the most important items in the management of a large garden, and here the individual who calls himself a "head working" gardener will be out of place. In an establishment of any pretensions, where the number of hands employed in the gardens may be anything from twelve to forty, it is a false economy on the part of the head, as a rule, to do any of the manual work himself. It must not be forgotten that, in the majority of gardens, a large section of the staff will be composed of boys and young men, with little or no sense of life's responsibilities, and that the temptation to idle away their time when no watchful eye is upon them is one too great to be resisted. Instead of actually doing things himself, therefore, the head gardener should spend a large portion of his time in seeing that others do them as he would wish. It is a false economy to employ young and comparatively inexperienced men as foremen. Next to the head himself, the well-doing of the garden is in the hands of

these men, and, though it may look well on paper to show a few pounds saving at the end of a year in this part of the wages list by employing low-priced hands, it is of very little use when there is a much bigger item on the other side of the balance-sheet for plants and other things which have been spoiled by careless handling.

Seed-saving. An important item in the management of a large garden is that of seed-saving. Seed of all flowers and vegetables that do well in a garden should be saved every year, and be stored away for sowing the following season. Careful attention to this branch of the garden work will effect a saving of many pounds on the annual seed bill, and the work of picking them over in order to separate the good from the bad is an operation which may readily be carried out during the winter days when there is not so much to be done out of doors, or at any time when inclement weather causes a cessation of operations outside. It is not economy to be constantly introducing novelties into a garden. Changes must, of course, be made from year to year, but thousands of pounds are wasted annually in this country in the purchase of seeds, plants, and bulbs which are boomed as being something new.

It is not too much to say that an economy of 25 per cent. can be effected in the cost of fuel for the hothouses where care is used. Sufficient fuel must, of course, be used to maintain the houses at an adequate temperature, and anything more than that is not only waste as far as the consumption of fuel is concerned, but is not in any way conducive to the welfare of the inhabitants of the greenhouses. It should not be forgotten that coal-dust, damped with a little water, and banked up in the boilers overnight, will preserve an equable temperature in a house till morning, without further attention. This is a far more economical plan than the general one of stoking up overnight with a mixture of coal and coke, which invariably has the effect of raising the house many degrees above its proper temperature during the early hours of the night, and letting it down dangerously by the time the darkest and coldest hour of all arrives—the one preceding dawn.

A watchful eye must be kept on the waste thrown on the rubbish heap. It is a common practice to throw away bulbs that have been forced, plants which have been pulled up in the process of thinning out beds, and other such things. All forced bulbs may be used again in a spot in the reserve garden to furnish a supply of bloom for cutting, and if there is no room for surplus bedding plants, or thinned-out vegetables, they may readily be exchanged or got rid of in other ways.

How to Label. Proper labelling of plants is a far more important factor in the economical management of a garden than is generally imagined. Except in the case of plants which are so generally grown that they cannot fail to be recognised by the merest tyro, it is well to have everything labelled inconspicuously, but at the same time clearly. This is particularly important in gardens where collections of the different species of a genus are made, as, although many of them are very similar in appearance, they require different treatment from each other. In the event of a mistake, therefore, it is easy to see that a lot of valuable plants may be lost through not being labelled at all, or labelled indistinctly. It may be well to state here that the writing on a label should always be commenced at the top end—that is to say, at the part of the label furthest from the point which sticks into the ground. The reason for this is that if the rain and decay tend to make the label illegible, the upper part of it is, in the ordinary course of events, sure to be clearer than that which is close to the ground. If this upper part, therefore, bears the first part of the name of a plant, it is usually easy to guess at the remainder; but if the writing of the label has been started at the lower part, in all probability the last few letters of it only will be legible, and confusion easily follows.

The Need for Tidiness. It need perhaps hardly be said that tidiness and economy go hand in hand in gardening. All such operations as weeding, rolling, mowing, the clipping of hedges, and the hundred and one operations which go to make the garden neat and pleasing to the eye, should be attended to promptly and frequently. It is easy for a lad to remove young weeds, for example, in a very short time when they first make their appearance, but if they are allowed to remain undisturbed for a few days, it is astonishing with what rapidity they will grow, and with what corresponding difficulty and expenditure of labour their removal will be attended. That well-known business maxim, "Do it now," cannot be too rigidly observed in connection with the gardening operations just alluded to if a true economy of time and labour is to be effected. On the other hand, it is well not to be too precipitate with the autumn and winter planting operations, and the carrying out of such schemes as summer bedding. The vagaries of the weather have to be considered here, and premature action in the work may allow a nip of frost to destroy everything, and hence, instead of an economy being effected, a further expense for new plants is incurred.

How to Become a Gardener. Although the oldest profession on earth, gardening is one which is most poorly paid, and the lad who is setting out with the determination to make a fortune should think very deeply before he decides to embrace horticulture as the means to that end. This remark applies more particularly to private gardens. There are plenty of instances on record of nurserymen who have accumulated large fortunes, and, although the market gardener is always pleading poverty, one very rarely sees members of his profession included in the official list of Receiving Orders in Bankruptcy; but in both these businesses there is, of course, a large element of risk. To qualify as a gardener it is necessary to start young. The orthodox way is to secure a berth in some large local private garden or nursery as a boy, at a wage which rarely exceeds 5s. per week. If a lad shows any aptitude the head gardener will be only too glad to push him on, and, in a couple of years time or so, his money will be raised to 7s. or 8s. a week, in addition to living accomodation in the "bothy." This "bothy" is usually an estate house in which the young unmarried gardeners in a private establishment live together, and take it in turns to act the part of housekeeper. If the "improver," as the embryo gardener is called at this stage, lives at home instead of in the "bothy," he is usually paid a shilling or two more per week. As he grows older and gains more experience he develops into a "journeyman." There is no doubt that at this time he gains the bulk of his experience, and if he wishes to learn his profession thoroughly he will do well to change his situation occasionally, and become acquainted with gardens in various parts of the country.

It must be distinctly understood here that the writer does not wish to advise lads and young men to throw up good situations, and go wandering about the

face of the land in and out of work every few weeks. If a gardener is in a situation which seems likely to be a permanent one, and the prospects of promotion are good, he will, of course, stay there if he is sensible. At the same time, experience gained in only one garden cannot be so varied or valuable as that obtained in two or three, where soil, aspect, climate, and dozens of other conditions vary.

Getting to the Top. By the time he is four or five and twenty years of age, the "journeyman" usually considers he has sufficient experience to dub himself a "foreman," and in this capacity he has charge of one part of the garden, under the immediate supervision of the head gardener. The number of foremen employed in a garden varies, but in a place of any pretensions there is usually one for the kitchen garden, one for the flower garden, and a third for the glasshouses and conservatories. His wages are now about £1 per week, and his share in the "bothy;" or 24s. a week, roughly, if he lives outside. The final step from foreman to head gardener usually happens automatically, when the horticulturist is lured into matrimony. He finds that a foreman's wage is not sufficient to support two, and therefore he endeavours to better himself by applying for a situation as head gardener. When he has succeeded in obtaining this he has risen as high as he can ever hope to do in his profession. His emoluments now consist of a salary of 30s. a week, with a cottage to live in rent free, and the privilege of having sufficient of his employer's coal, fruit, and vegetables, for the consumption of himself and family. There are very few gardeners indeed in the United Kingdom who, though they may have charge of places in which thirty or forty men and boys are at work, receive a higher wage than that just mentioned, an income which, in cash and kind, rarely exceeds £150 a year.

Growing for Exhibition. Growing for exhibition at flower-shows is another of the gardener's methods of increasing his income, if his employer does not object. There is hardly a village in the United Kingdom that does not hold its annual flower-show, and many gardeners exhibit at every show within a reasonable radius. The prizes are not large, certainly, ranging as they do from a shilling to a sovereign, but they amount to a considerable aggregate with a consistent exhibitor. The majority of employers are very willing for their gardeners to compete at these flower-shows, and willingly buy exhibition varieties of different plants to facilitate their chance of winning, thinking, as they rightly do, that success at flower-shows is a proof of the skill of their gardener, and an incentive to spur him on to further efforts. At the same time, however, it must be remembered that too much showing is a bad thing. A head gardener who is constantly exhibiting is apt to devote too much attention to his "show" plants, to the detriment of the garden work generally; while his constant absence at the shows themselves, brought about by the necessity of staging and removing his exhibits, is likely to make things get slack in the garden all round. Exhibiting, therefore, should only be done in moderation.

How to Succeed as a Nurseryman and Seedsman. The difference between a florist and a nurseryman and a seedsman is a simple one. The florist is not a producer, but is generally merely an agent for the disposal of goods grown by other people. The nurseryman and seedsman, on the other hand, sells plants and seeds which are the result of his own cultivation and skill. It must not be imagined, however, that nurserymen sell nothing but what they have raised themselves, as large quantities of seeds and bulbs are imported annually, chiefly from France and Holland, to enable them to fill orders which they could not execute from stock of their own raising [see page 4967].

Roughly speaking, nurserymen and seedsmen may be divided into three classes. At least 70 per cent. of them do the bulk of their trade in penny and twopenny packets of seeds, and cheap bedding plants. About 20 per cent. of the remainder have a better class of trade, an important feature of which is the laying out and keeping in order of suburban gardens by contract. The remaining 10 per cent. or thereabouts represent the élite of the trade, who, as a rule, supply only seeds of the finest quality, grown by themselves, and the latest novelties, for which they can command high prices.

How to Start. In normal times undoubtedly the best situation for a nurseryman and seedsman who contemplates starting in business is in the outer suburbs of London or one of the other great cities. In such a situation he will be able to grow plants and produce seeds, free from the taint of city smoke, though, at the same time, they will be hardy enough to withstand the rigours of town life. A large portion of his trade will be purely local, although the postal department of a nurseryman's trade is one which ought never to be neglected. Naturally, the greater portion of the stock of a seedsman who caters for the million will have to be purchased by him from the wholesale houses in bulk, and made up and retailed in small quantities. Much of the success of the retailer will depend on the quality of the seed he thus dispenses. If he is careful to deal with wholesale firms of high standing, our young nurseryman is, at all events, sure of giving satisfaction to his customers.

A certain amount of seed of such things as calceolaria, petunia, lobelia, and other popular plants should be sown very early in the year in heat, with a twofold purpose in view. Some of the plants so raised will be required in the late days of spring and early summer, either for selling to chance customers, or for the purpose of fulfilling any contracts to keep gardens and window-boxes in order which the nurseryman may have been fortunate enough to secure. Keeping gardens in order by contract is a very profitable branch of a nurseryman's business, and a good trade may often be done in this direction by a local canvass of likely houses during the months of April and May.

Mail Order Business. If this branch of his industry should at first not come up to his expectations, there is another channel through which the nurseryman can dispose of any plants he may have on hand. This is by means of advertisements in the horticultural journals, bearing always in mind the fact that the nurseryman should draw up his advertisement with a view to disposing of what he will have ready for sale in a fortnight or three weeks' time. Most horticultural journals go to press at least a week in advance, and the consequence is that plants, which may be ready for disposal at the moment of drawing up the advertisement, will be past their best time for transplanting when the announcement is made public, and orders begin to come in. Intelligent anticipation will do much to assist in this branch of the business.

Silk Hand Dyeing. Machinery for Dyeing. Yarn and Warp Dyeing. Jiggers. Padding Machines. Washing and Drying. Dyeing of Special Non-textile Materials.

DYEING MACHINERY

MACHINERY driven by power came into use in dyeing practically with the artificial dyes and the subsequent enormous expansion of the trade. When the dyer had to deal with small quantities of goods—a few bundles of yarn or a small piece or two of cloth—he was content to use vats sunk in the level of the dyehouse floor, as in the old and still-used process of indigo dyeing, and with tubs and kettles, working the goods with his hand, or, if the heat would not allow this, with rakes or forks or with a long, crutch-like stick known as a "jigger." The resemblance of a billiard-rest to this article has given us a familiar slang-word.

Hand Dyeing. Dyeing by hand is still largely practised; it is the rule in treating delicate fabrics such as silk. In machine dyeing complete and easy solubility of the dye-stuff and level dyeing properties are necessary; in hand dyeing any drawbacks in these respects can be more easily overcome. Fabrics are simply "worked" in dye-kettles by means of a pole or jigger, and yarn is dyed in a vat. The ordinary form this takes is simply a strong, oblong box, fitted with a steam-pipe below a perforated false bottom. The steam may be either blown in direct, or a closed steam-coil may be used. The latter is usually preferable.

In dyeing hanks or skeins, the hanks are strung in festoons on sticks. These are ordinarily straight, but in some cases—in using the sulphur dyes, for instance—they are bent so as to keep the yarn constantly under the surface of the bath. The hanks are dipped into the bath, raised and lowered in the liquor a few times, and then left in the bath, with the ends of the stick resting on the edges of the vat. The next stickful is then introduced in the same way; and when all have been entered, leaving a space between each to prevent entanglement, the first is lifted by two men, standing one at each side of the vat. One of them thrusts a stick through the hanks, and when the other has grasped his end they lift the hanks so that they are well turned on the stick, and the part of the yarn that was resting on it is now in the bath. The others are treated in the same way, and the yarn is said to have had "one turn." The men go on to give "three turns" or more, according to their judgment or instructions.

Foam Dyeing. This is a system of treatment in which the material is dyed not in the liquor of the dye-bath, but in the froth arising from it produced by the action of jets of steam. It has been used very successfully for cotton fabrics and for silk. The diagram [1] merely shows the principle of the apparatus, which, it will be gathered, consists of a vat with a grid at A, over which the goods to be dyed are packed. The dye-bath, B, must not rise above the level shown at D, as only the froth must act upon the goods. A perforated pipe, C, blows in steam, which sets up a strong foam, the concentrated dye-bath needing only the addition of a little Turkey-red oil. The bursting bubbles have extraordinary penetrativeness, and the material can be closely packed down upon the grid A. With a closed-in apparatus on this principle the dyeing of cops and cross spools has been successfully effected.

The Wince. The dye-beck with a wince represents the simplest form of machinery in the dyehouse. A skeleton roller is mounted on a wooden box capable of containing 250 to 300 gallons of water, and this is the wince, frequently pronounced and even written "wench," of the Yorkshire dyehouses. The cloth is stitched in an endless band, passed over the wince and round guide rollers in the dye-beck. It is then run through the bath either by power or by hand until it is evenly dyed to shade. It can be mordanted and washed in the same beck. This apparatus is especially useful in woollen piece-dyeing where the goods must be treated in long baths—*i.e.*, in plenty of liquor, which must be kept boiling.

For heavy cotton goods a rather more complicated machine known as a jig wince is useful. This may also be used for warp dyeing and for washing after dyeing in the jigger. The cloth is not drawn immediately through the bath, but is allowed to lie in folds, in order to give the dye plenty of time to act on it.

Dyehouse Machinery. Broadly speaking, the form of machine used differs little with the kind of fibre under treatment, but widely with the state of manufacture. In other words, a cop of yarn cannot be dyed like a piece of cloth, nor will muslin stand the treatment of strong cloth or felt. The careful manipulation required for silk makes it necessary to dye it by hand or with a simple form of machinery not liable to damage the fibre. The quantities ordinarily dealt with, moreover, allow most of the dyeing to be done by hand in wooden dye-vats, or even in earthenware or porcelain vessels. It is dyed in the form of yarn or cloth; and in a few of the largest silk dyehouses some of the simpler forms of machines used for dyeing cotton in the hank and in the piece have been adopted, in order to handle quantities rapidly.

In one form of special machine for silk yarn the hanks are placed over a reel, free at one end, so that they may be readily put on and taken off and run through a dye-vat, the reel or rollers revolving so as to pass every part of the hank continuously through the dye liquor. In another form, the hanks are hung on a pole, or between two poles, and carried through the dye-bath with a revolving action, to ensure even dyeing. As regards pieces, the wince arrangement already described is used, or a simple dye-jig, which will be described later.

Wool and Cotton Dyeing. Wool is dyed as the loose raw material, but the bulk of it is treated in the form of slubbing or in the woven state. Cotton is dyed in the raw state and in every stage of manufacture, as sliver, rovings, cops, or cross spools, in the hank, in the warp, and in the woven fabric. For each of these forms of material a multiplicity of special machinery has been devised; and in this course it will be requisite to confine ourselves to typical machinery, and in most cases we endeavour to show the principle of the

action rather than the actual machines. It may be here stated, without fear of contradiction, that British engineers are pre-eminent in this branch.

Loose Fibre. The advantage of using coloured weft cops, obviating the necessity of any subsequent reeling before the introduction into the shuttles, is evident in the manufacture of fancy and parti-coloured fabrics. It is obvious that one way out of the difficulty of dyeing tightly wound cops through and through is to dye the wool or cotton before spinning. Technical difficulties, however, for long stood in the way. It was not easy to ensure sufficiently even penetration to get uniform results; wool was liable to felt, and cotton lost its "nature," as the spinners say, so that in either case spinning was difficult and possibly imperfect. These defects have been largely remedied by the recent use of Turkey-red oil or the polysulful oils and soaps introduced by a Lyons chemist, M. Juillard. These assist penetration and preserve the nature of the raw material.

The Klauder-Weldon machine has been used for loose cotton, but it is unsuitable for wool. It is very similar to the modern washing-machine in the steam laundry; a drum of copper netting containing the loose material revolves in a heated dye-bath until the dyeing is effected, and it is obvious that by changing the baths, the same machine may be used for bleaching, mordanting, or washing. A much-used machine for loose material is that of Obermaier, manufactured by Messrs Mather & Platt. In this the loose material is stationary, the liquor being forced through it, a point particularly important in the case of wool as felting is avoided. Part only of the machine is shown in the diagram [5]. The circulation of the liquor in the direction of the arrows is effected by a centrifugal pump, A.

Sliver or Slubbing. The advantages of the dyed cop are better obtained by dyeing what the spinner calls "preparation"—that is to say, the cotton in some state of preparation for the spindles. After it has been opened and scutched, a great amount of dirt has been removed which interferes with the purity of shade when raw cotton is dyed; and if it has been carded, the injury done to the cards by the mordant is obviated.

A fresh difficulty, however, arises. The woollen slubbing or cotton sliver must not be broken, and even cotton rovings would not stand the treatment which is allowable with raw cotton. The Obermaier machine, in which the material is left undisturbed, is also the standard apparatus for the purpose. The movable copper cylinder, B, can be lifted out of the dye-vat by means of the hook, C, by means of a travelling crane. The vat is heated by steam. When the cylinder, which is varied in formation somewhat, according to the material to be dyed, is packed with the goods, it is lowered into the vat, steam is turned on, and the centrifugal pump is set in action. This circulates the dye liquor in the vat through the goods by means of the perforated centre tube, and back into the vat again. When the desired shade is obtained the cylinder is lifted, and goods are removed and hydro-extracted. They may be washed in the same receptacle or dried in it by means of a current of hot air if desired.

Cop Dyeing. The cop is yarn as it is taken from the spindle. It is very compact, and consequently very difficult to dye. The advent of the direct cotton-dyeing colours has, however, assisted the cop dyer, as they have great solubility and do not require mordants, which form a solid lake on the fibre and interfere with the penetration of the inner layers of the cop. In dyeing, the cop is mounted on a hollow perforated spindle, and placed in a machine which forces or sucks the liquor completely through the yarn, or both alternately. Weft cops for dyeing or bleaching are not mounted on the narrow paper tubes ordinarily employed in spinning weft (paper bottoms), but the first layers of yarn on the spindle are stiffened with a little paste (paste bottoms). As in dyeing loose material, the main difficulty is the question of even penetration. The liquor has the natural tendency to take the line of least resistance, with the result of want of uniformity of shade throughout the cop. Penetration is assisted by the addition of spirits of wine or a sulphonated oil to the bath.

The principle of a cop-dyeing machine is shown in the figure [4]. Perforated spindles are arranged round the surface of a cylinder, as shown in the detail, B, and this is immersed in a dye-bath. The tube, D, is connected with an air compressor, and E with a suction pump. The action of these drives the dye liquor, via the tube, H, through the cylinder and the cops on it. When the vat is sufficiently full, a vacuum is created in C, and the action is reversed. The liquor passes back through the cops into the cylinder, and is drawn back into C by the tube, F. This alternate action is continued until the cops are thoroughly dyed.

Cheeses (small warps resembling a single Gloucester cheese) and spools (yarn wound, for instance, by means of a split drum) are dyed and bleached in the same form of machine, with slightly different mounting arrangements for the cheese or spool. As the yarn is less tightly wound, it is easier to get level shades throughout than in cop dyeing.

Beam Dyeing. This is one of the latest developments. Yarn is now dyed on perforated beams. The dye liquor is forced through the material by means of pumps, much after the manner of dyeing cheese warps. The advantage is that a back beam of large dimensions can be dyed ready to serve as warp in the loom. The principle of the machine used is shown in the illustration of the cop-dyeing machine, the perforated beam replacing the cylinder, A.

Hank or Skein Dyeing. The hank is the reeled yarn, and presents the form that is familiar to the public in skeins of thread. It requires very simple machinery; in fact, in dyeing yarn in hanks, the only thing to be avoided is the entanglement of the yarn. The simplest form of apparatus has already been described under hand dyeing, and is still very much used, especially when many small lots of yarn have to be dyed different colours.

A typical form of yarn-dyeing machine is the Klauder-Weldon. In this the yarns are arranged on a pair of rods suspended between two revolving discs, which carry the yarn through the dye liquor contained in a semi-cylindrical vat. The hanks are steadily carried through the dye liquor, and, there being no motion of the hanks, there is no chance of any entanglement. The machine works very successfully, is simple in operation, not liable to get out of order, is capable of dealing with large quantities of yarns, and is economical of dyestuffs.

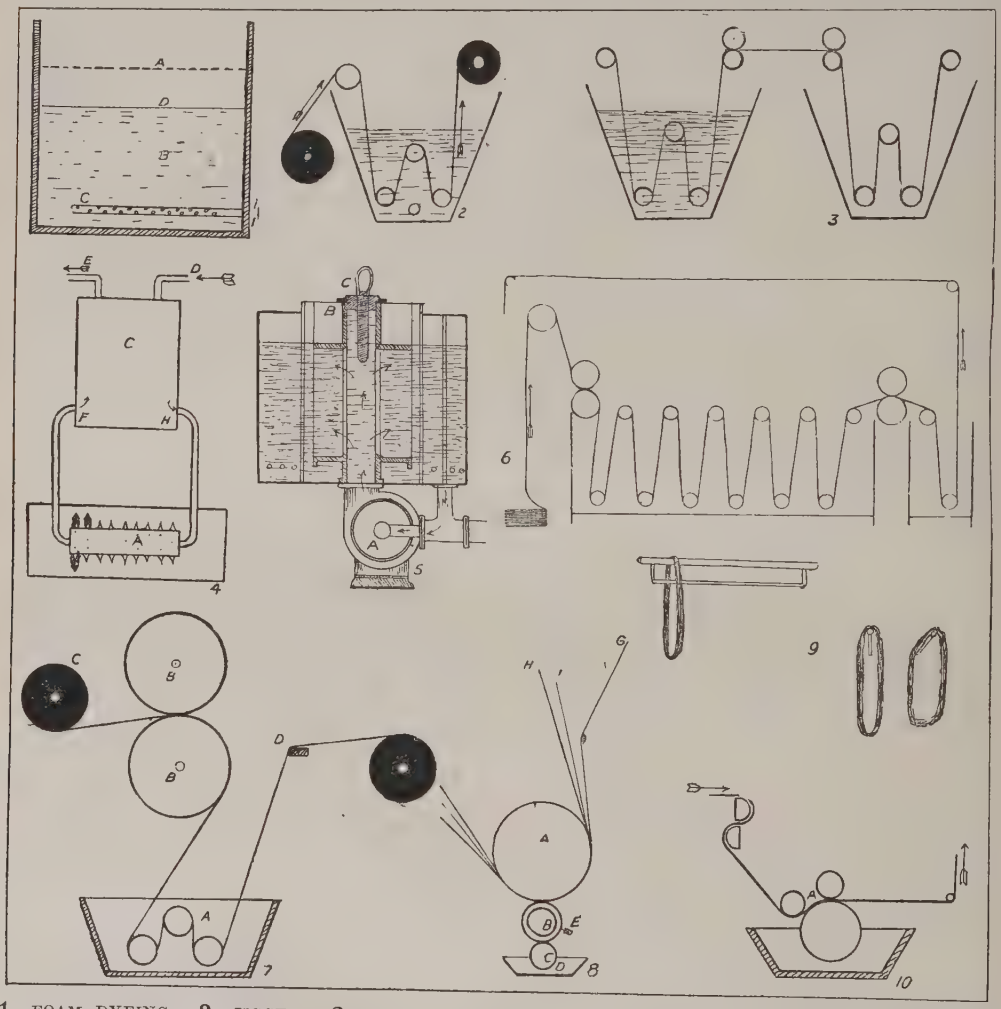
A very ingenious yarn-dyeing machine is that of Corron. In this a rectangular dye-tank is provided, and over it a travelling arrangement which,

in passing from one end of the tank to the other, picks up the rods full of yarn, turns them over, and drops them back again. The simple arrangement by which the hanks of yarn are turned over in the dye-bath is shown in the diagrams [9]. Hand-work is closely imitated by this machine.

A perfect hank-dyeing machine would seem to be one in which either the hanks are kept still and the liquor is caused to circulate through them, or one in which the hanks are carried through the dye liquor, but must not, while doing so, be subjected to any rapid movement tending to bring about entanglement of the hanks one with another. The hanks should not be tightly stretched, but hang somewhat loosely, because then the dye liquors can more thoroughly penetrate to every fibre of the hank.

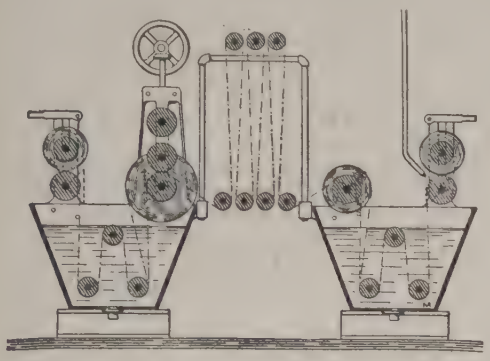
Warp Dyeing. Warps are collections of yarns in long lengths, ready for the loom. They come into the dyer's hands in several forms, but usually in large balls of about 12 in. in diameter (ball warps). In the process of dyeing, the threads must not be entangled, otherwise they will not lie straight on the loom or pass freely through the eyes of the healds, and so breakages will occur that are undesirable.

The usual plan of warp dyeing is to have a vat as in the diagram [6], with a number of guide rollers at the top and bottom, and to pass the warp round these rollers, and thus, as it passes through from the first to the last roller of the set, it travels several times through the liquor. By running the warp backwards and forwards, giving it several "ends," it can be effectually dyed. This method works well; the threads of the warps can be kept level and straight, and the dyeing is uniform. It necessitates the unwinding of the ball of warp in the first instance on to a winding roller, and, when dyed, rewinding back again into the ball form, although, if the dyer be also the manufacturer, this rewinding may be omitted, and the warp wound ready for use on the warp beam.



1. FOAM DYEING 2. JIGGER 3. PAIR OF JIGGERS 4. COP-DYEING MACHINE 5. OBERMAIER MACHINE 6. WARP-DYEING MACHINE 7. PADDING MACHINE 8. SLOP PADDING MACHINE 9. HANK-DYEING: CORRON METHOD 10. PADDING ANILINE BLACK

The problem comes up whether the warp could be dyed in the ball form, with all the threads in position and undisturbed. If it could be done efficiently, and the colour be level throughout, then this method would save the trouble of unwinding and rewinding the warp. Now, simple immersion of the ball of warp into the dye liquor will not do, for it will not come up of a level shade. The dye liquors are found not to penetrate right



11. PAIR OF JIGGERS WITH AIRING FRAME

into the centre of the ball warp, and so the outside gets dyed the deepest shade while the centre either does not get dyed at all or only a pale tint. This want of penetration is caused by the tightness with which the ball is wound acting as a resist to the penetrative capacity of the liquor; and, secondly, there is no doubt that the air enclosed in the interstices of the warp in the interior of the ball, prevents the liquor from getting into the central parts, because the liquor in turn prevents it getting away with sufficient freedom. What is wanted in order to dye a ball warp is some means of forcing the dye liquor right to the centre. Winding the warp into an Obermaier apparatus would do very well, and perfect results can be obtained, but, as with the warp-dyeing machine, this necessitates unwinding and rewinding of the balls. Placing the warp into a closed chamber and circulating the dye liquor through is an improvement, but even then there is much chance of the centre being paler than the outer portions. A better plan would be to wind the ball on a spindle in the first instance, and then to put the ball on a hollow perforated spindle through which the liquor can be forced. In this way a modified Obermaier can be used, and good results attained.

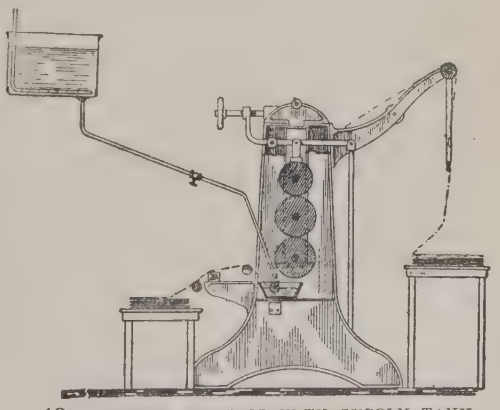
Jigger Dyeing Machine. The action of this simple "dye jig" is sufficiently explained in the diagram [2]. The cloth is wound on a roller round the guide rollers shown at the bottom of the vat, and round a second roller. This is revolved, drawing the cloth through the bath and winding it. When all the cloth wound on it has had "one end," the action is reversed, and it is given as many ends as necessary. Then it is "batched" on to the larger roller shown to the left of the diagram. This "batching roller" is then removed for subsequent processes—washing, drying, etc. The reversal of the motion of the rollers is automatic, and there are simple arrangements for regulating the tension of the cloth. In dyeing calico and unions in the full width, this is perhaps the most universally used machine. The jigger is used for dark shades, as strong short baths can be used.

When heavy drills or thick cloths generally are under treatment, the use of the squeezing rollers is advisable, as they effectively drive the liquor into the goods. Only one batching roller is shown, but a similar roller can be mounted on any of the outstretched arms, either to the right or left of the vat. For the purpose of attaching the cloth to the rollers, it is a common practice to sew a piece of cloth tightly round each roller, leaving a loose end to which the piece can be attached. In the place of the single guide roller shown over the vat at the left of the figure, squeezing rollers are often provided. These press the excess liquor back into the dye-bath.

Jiggers are very often run in pairs, the diagram [3] showing a pair with squeezing rollers. The right-hand vat is empty, this arrangement being sometimes adopted for sulphur colours; the goods are dyed in the first vat and oxidised in the second. It is obvious, also, that the second vat can be used for rinsing; or sometimes it is convenient to carry out the dyeing operation in both jiggers, running the cloth through them continuously. For the sulphur dyes and vat colour an airing frame [**11**] is mounted between the jiggers, and squeezing rollers are necessary.

There are many forms of jiggers for various purposes. The most modern is, naturally, for the vat colours. In this the goods are wound backwards and forwards between two rollers under the surface of the liquor.

Spiral Dyeing Machine. In this machine the cloth is not in tension, and may be dyed in separate pieces between pegs on the top roller, or stitched together "on the endless system." The pieces on the continuous band traverse the *beck* in a spiral, a loop at the bottom keeping the cloth fairly slack. This slack loop allows the cloth to remain longer in the liquor and promotes even dyeing. The machine is much used in dyeing on a large scale, as the beck can be made of any

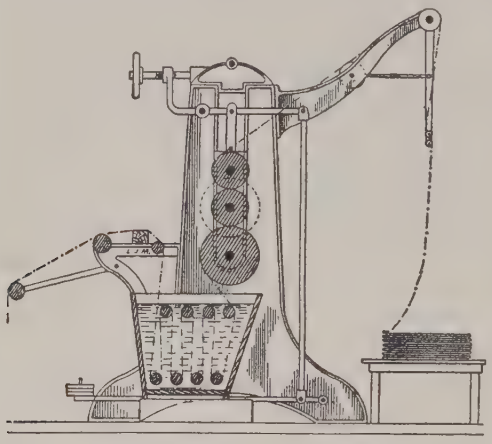


12. PADDING MACHINE WITH SUPPLY TANK

practicable length, capable, say, of dealing with thirty pieces at a time.

Circular Back Machine. This is a form of the dye-beck and wince for cloth already described. It has a small cylinder engine attached, and the wince is driven by a reversible eccentric, so that the cloth can be run through the bath either way as desired. This is principally used in Leeds and Huddersfield for West of England cloths.

Hawking Machine. This is used in dyeing when it is necessary to keep the cloth under the surface of the liquor throughout the operation to guard it from exposure to the air. It consists of a series of guide rollers arranged in the dye-vat so that they are completely covered with the fabric, which is drawn continuously at full width through



13. JIGGER PADDING MACHINE

the bath by means of a pair of rollers, also, of course, under the surface of the liquor.

Padding. As the name implies, this is a rapid method of dyeing cloth, suitable only for light shades. When one side only of the cloth is covered, this is called "slop-padding," a style of work very suitable for discharge effects. The ordinary padding machine consists of a trough containing guide rollers, and with a pair of squeezing rollers above it. The cloth passes through the dye liquor in the trough, round the guide rollers, between the squeezing rollers, and away.

In the two-roller padding machine shown in the diagram [**7**], the vat, A, contains the dye liquor, which is usually thickened with starch and gum tragacanth. The block, D, is provided to give a little drag on the cloth, which passes under and over the guide roller in the vat, through the nip of the squeeze rollers, B, and is then batched at C. In a three-roller machine [**12**], the cloth passes through the bath, then through the nip of the two lower rollers, through the bath again, and through the nip of the two upper rollers. The amount of colour taken by the cloth depends not only upon the strength of the dye-bath but also upon the pressure of the squeeze rollers.

In "slop-padding," the piece passes as shown [**8**] round the large iron roller, A, which presses against the copper roller, B. The roller B is fed by a wooden roller, C, running in the thickened colour in the box, D. This is actually a printing process, and the cloth does not run through the dye-bath. The printing roller may be engraved with fine lines to enable it to take up more or less colour according to the depth, and, as in the printing machine, it is provided with a doctor, E, to scrape off the excess colour. Between the cloth, G, and the iron roller A is a blanket, the elasticity of which enables the cloth to take the colour. This is marked H, and a back cloth, I, is often provided, to prevent the blanket from being soiled. In aniline black dyeing, and in some other styles, the cloth is often printed with a reserve, and in this case a slop-padding machine is used, as shown in the diagram [**10**]. The goods are guided between two rollers, with the printing side pressing against the lower one, which is of much larger diameter than the upper roller and turns in the bath. The roller A keeps the cloth in touch for a few inches with the colour, to enable the fabric to take up sufficient dye. The reserve prevents the dye from going on to places where it is printed, and thus produces a pattern, in white or in colours as the case may be. Instead of a blanket, the penetration is regulated by the pressure of the upper roller, which is covered with indiarubber.

The jigger padding machine [**13**] combines the advantages of dyeing and padding, giving very thorough penetration.

Continuous Dyeing Machine. As shown in the diagram [**14**], this is usually made with four or five compartments, each with its own pair of squeezing rollers, the upper one of each pair being coated with rubber. The first compartment is for wetting out, the others for dyeing, rinsing, and after-treatment, as required. As a rule the dye and other liquors are supplied from overhead tanks; and when the speed of the machine and the rate of the inflow is fixed, the process is practically continuous, and allows a large output of work with a minimum amount of labour and attention. This machine is also used for *diazotising* and developing, but in this case three compartments are sufficient, as shown in the diagram [**15**]. The pieces previously dyed and washed on another machine are transported to this apparatus, the first box of which contains the nitrite of soda and hydrochloric acid for diazotising; the second box, B, the rinsing water, slightly acidulated from the hydrochloric acid tank, and the third, C, contains the developer. Each compartment is separated, as shown, by heavy squeezing rollers.

Steaming. After dyeing, some colours—for instance, aniline black, Turkey-red, and many of the alizarines—require steaming under pressure to develop and brighten the colour. Messrs. Mather & Platt's "Cottage," steamer is universally used. It is a strong wrought-iron cylinder, one end of which gives access by means of a sliding door with counterweights. It is used either for yarn or cloth, and the position of the goods round the rollers can be varied from time to time by moving the exterior handle.

Any pressure up to 30 lb. per square inch (roughly, two atmospheres) may be applied.

Soaping and Washing Machine. This continuous open-width machine can be made with any number of cisterns from one to twelve. In its most general application it is used as a combined raising or fixing, soaping and washing machine. Besides this use, it can also be employed with advantage for "cutting" indigo-dyed goods, developing naphthol colours, or chroming aniline blacks.

A medium-sized range, with six cisterns, can be used as follows: (1) raising or emetic cistern; (2) washing cistern; (3 and 4) two soaping cisterns; (5) clean soap cistern; (6) washing cistern with heavy squeezing bowls. With the exception of the raising cistern, all the cisterns are fitted with beaters of non-corrodible metal, placed below the surface of the liquor and between the vertical laps of cloth. These beaters are driven independently at a high speed, whatever may be the speed of the

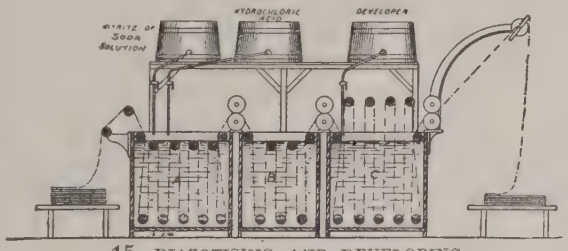
cloth through the range, and they dash the liquor with great force upon both sides of the cloth, thus thoroughly cleansing it and loosening and removing any thickening matter which may have been used in the colours, and any by-products from the use of mordants or discharges, while not the slightest injury is done even to the most delicate fabrics.

Wringing, Squeezing, and Hydro-extracting. The wringing post has a hook or sort of short perch upon which yarn can be twisted by hand to drive off excess of moisture. In squeezing, rollers are provided upon many machines, through which the yarn or cloth passes, and the excess liquor runs back into the bath. By taking advantage of the law of centrifugal force, much more moisture can be driven off by means of a hydro-extractor. In wringing, less than 50 per cent. of moisture is removed; by squeezing, about 70 per cent.; whereas over 80 per cent. is driven off by "whizzing," as it is familiarly termed. The hydro-extractor is now largely used in the steam laundry, and the economy of this preliminary drying process will be apparent.

14. CONTINUOUS DYEING

The hydro-extractor is a perforated metal basket, mounted in an outer case, so that it can be revolved at a high rate of speed. The goods are packed into the inner basket, and the machine is set in motion, revolving at the rate of 1500 revolutions per minute. The water expressed by the powerful centrifugal force is thrown into the case, and escapes by means of a drain pipe. Hydro-extractors vary in detail according to the special use to which they are put.

Washing. Thorough washing is one of the most important processes in the dyehouse, and it is one that might have to be repeated several times in the stages through which the goods pass before they are ready for the market. All surplus mordant must be washed off before dyeing, otherwise it forms insoluble lakes in the dye-bath, wasting colour and leading to spotty dyeing. As a rule, but not always, the goods must be washed after dyeing, to clear the fibre and to freshen the colour. As we have seen, the mordanting, dyeing, and washing may proceed as a continuous operation in a machine with several "holes," or the beck, or jigger, may be cleared of liquor and filled with clean water. Special machinery, however, is useful in some cases.



15. DIAZOTISING AND DEVELOPING

Drying Cylinders. The machine for drying both sides of the cloth takes the form of a number of cylinders [16], heated by steam. These were all formerly, and are still as a rule, made of tin-plates, and hence are commonly known to the finisher as "tins." The cylinders are heated by steam passing through their hollow axles, and revolve as the cloth passes over them, thus constantly bringing up a fresh heating surface. In diagram 16 the cylinders are shown in an horizontal position, but they are often mounted vertically.

Steaming and Ageing. The continuous steaming and ageing machine is referred to in all technical literature as the "Mather & Platt," a sufficient testimony to its universal application. It is a chamber fitted with a number of copper rollers to guide the piece while passing through. It is used for a large number of colours, which are developed by steaming, and for ageing (*i.e.*, oxidising) aniline black, the steam acting as an oxidising agent. In the latest machines two or more "runs" of cloth can pass abreast. This enables a chamber of half the height or length of those constructed for a single run of pieces to turn out the same quantity of cloth.

NON-TEXTILE DYEING

A very large number of articles are coloured artificially for one purpose or another. Leather, paper, straw, and feathers are the most important of these. Volumes have been devoted to the many methods of dyeing these materials, and in the short space at our disposal in this course it will be possible only to touch on the broad principles of the art.

Leather. In leather dyeing the effect produced depends upon three perfectly distinct causes. One of these is the mechanical inclusion of dyestuff in the pores of the material—that is, its imprisonment in interstices which nothing can reach except a liquid. In these spaces the dye is deposited in the solid form by the evaporation of the solvent, and is protected from external agencies by the surrounding walls of leather.

The second cause is the chemical combination of the dye with the leather material itself. Like wool and other animal substances, leather has a strong affinity for certain dyes.

The third is the production of a lake by combining the action of the dye solution on the leather with that of a mordant. When tannin or chrome is used in preparing the leather from the raw hide, it plays a double part by acting as a mordant as well.

The choice of dyes depends largely upon the manner in which the hide has been prepared. There are three principal methods. One is with inorganic salts, especially with those of chromium and iron; a second is with tannin, while the third is chamoising, or preparing the skin with an animal fat, such as fish oil. It is easy to see that if these methods are combined, as is often the case, the difficulties of the dyer are much increased.

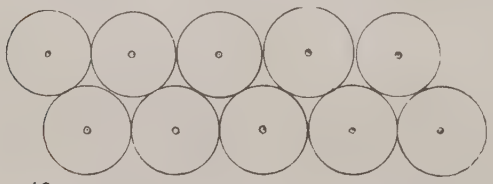
Dyeing Varieties of Leather. The main principles underlying the dyeing of the three sorts

of leather may be stated briefly. With oak-bark leather, or other leather tanned by natural tans, attention must be paid to the natural affinity for dyes of the leather itself, and the utilisation as a mordant of the free tannin present in excess so as to economise the use of the other mordants. With chrome leather regard must be had to the lake-forming properties of the metallic oxides present.

In the case of chamois leather we have to rely either upon the chemical affinity of the dye for leather or upon mordanting, or to take advantage of both. It is in many cases necessary to remove the superfluous grease before dyeing, as its presence not only hinders the absorption into the pores, but forms an insulating layer preventing due contact between the fibre and the chemicals.

The dyer of bark-tanned leather is dependent entirely upon the previous treatment. It is quite impossible to dye properly a badly tanned leather. The flesh side must be perfect, or no care will prevent the formation of streaks and spots. The tan must also be uniformly distributed through the entire mass of the leather, or the same results will ensue. When a leather has been dyed which is nearly but not quite faultless in these respects, it may seem unexceptionable on leaving the dyer's hands, but it will be sure to develop inequalities of shade after exposure to atmospheric influences.

Dyes for Leather. Tan leather is dyed with coal-tar dyes, with colour lakes, and also with direct vegetable and mineral colouring matters.



16. ARRANGEMENT OF DRYING CYLINDERS

Nine-tenths of the leather dyed is dyed with coal-tar dyes. Genuine Russia leather is dyed black with logwood on a mordant of alum and copperas, and red with sanders wood on an alum mordant. Other colours are dyed with anilines. Most dyers use logwood for black, the full black being secured with a little fustic. Cutch, which combines tannin and dye, is largely used.

In dyeing with coal-tar colours which require a mordant, lactic acid, bichromate, tartar-emetic, yellow prussiate, and the sulphates of alumina, iron, and copper are those chiefly employed. Most of the coal-tar colours used are, however, substantive dyes, and the shade is regulated by the strength of the bath. Tannin-dyed leathers take neutral or basic dyes without a mordant, and acid dyes if mordanted. Alum-tanned and chrome-tanned leather take acid dyes substantively.

The great object to be gained on tanned leather used for bootmaking and in upholstery is fastness to light. In the case of boots, the dye is, or ought to be, protected from weather by the usual dressings. Hence the dyer picks such dyes as are fast to light, and, when possible, those which require no mordanting. It has been found that if bark-tanned leather is painted over with an ammoniacal solution of an alizarine, and then mordanted with alum or iron, a good colour can be got without much heating, which would tender the leather. It is found that the use of iron or aluminium salts as basic as possible is desirable ; the neutral salts do not easily form lakes with alizarines, with the result that a good deal of the dyestuff is wasted. Basic nitrate of iron appears to answer every requirement in this connection, and is effective at hand-heat.

Dyeing Chrome Leather. Chrome leather dyes directly with great ease with any acid coal-tar dye, the only precaution necessary being that the leather should be thoroughly wetted before entering the dye-bath. For neutral or basic aniline dyes, a previous mordanting with sumach is necessary for light shades. For darker shades the sumach is replaced with fustic, and for the darkest with a mixture of fustic and logwood. Alizarine dyes answer very well for chrome leather, because the material stands the high temperature required, which bark-tanned leather will not do, except by the special treatment above mentioned. Chrome is the best mordant for alizarines generally. Lactic acid is a very useful assistant mordant for chrome leather if specially fast shades are required. It should be pure, however, as impurities are extremely apt to produce unlevel shades, especially with dyewoods or sumach.

Chamois Leather. Chamois leather can be mechanically coloured by rubbing in any desired pigment. If, however, it is to be dyed with a substantive or adjective coal-tar dye, it is freed from fat by washing, and then dyed exactly in the same way as tanned leather. For light shades, a preliminary bleaching is usually necessary, and this is generally done with sulphurous acid and permanganate of potash. When the leather has become a full brown by impregnation in the permanganate solution, it is rinsed and put into sulphurous acid solution just sufficiently long to remove the precipitated oxide of manganese. It is then rinsed and dried. Sulphurous acid alone cannot be used, as it tenders the leather and does not bleach it thoroughly.

Dyeing Paper. The mineral colours are largely used in dyeing paper. While the earliest procedure was to amalgamate the dye with the size, and thus to apply it to the paper after manufacture, it has now been found much better to dye the pulp, thereby securing the colouring of the paper through its whole thickness. This operation is by no means so difficult as cotton or wool dyeing, inasmuch as it is only necessary that the colour should not rub off, should be fast to light, and should not injure the cohesion of the paper. Hence the papermaker has a very large choice of dyes; and as the mineral dyes are especially cheap and fast to light, his preference for them is easy to understand, although they act prejudicially upon the durability.

The most usually employed of these mineral dyes are ochre, chrome yellow and chrome red, prussian blue, ultramarine, graphite, and lampblack. These, very finely ground, must be added to the pulp, either in a pulp mill or in a vat provided with a stirrer. The stirrer is necessary with heavy substances such as red-lead, litharge, chrome yellow, and manganese, on account of their great tendency to settle to the bottom of the vat.

Some few mineral dyes can be actually made in the pulp, as, for example, prussian blue, by adding to the pulp ferric chloride and potassic ferrocyanide, ochre by adding ferric chloride or ferrous sulphate and milk of lime. By generating the dye in the pulp itself, it is got in a finer state of division than is attainable by grinding, so that the colours are brighter and more uniform.

Mineral Dyes for Paper. It is, perhaps, unnecessary to say that the fineness of the tints depends also upon the constitution of the pulp, and for pure lively colours the latter must be carefully chosen or previously bleached.

Yellows and Oranges. Chrome yellow, which is absolutely fast to light, is the best yellow. By adding reds to this, any desired orange hue can be obtained. Ochre is best generated in the pulp, on account of the labour required to grind and levigate it properly.

Blues. Turnbull's and prussian blues are readily generated in the pulp, and are even to this day unsurpassed by any coal-tar colours. In using ultramarine, any excess of acid or of sulphate of alumina must be absent from the pulp, as both destroy the colour.

Greens. Seventeen parts of chrome yellow and one of prussian blue gives an almost pure green. Different shades are, of course, procured by altering these proportions.

Blacks. Of special importance for grey shades of black are lampblack and graphite.

Vegetable Dyes for Paper. As regards vegetable dyes, logwood, fustic, and cutch are chiefly used, on account of their cheapness and comparative fastness to light. Logwood is used either for darkening other dyes or for making a lake of a dirty violet hue by boiling the logwood extract with tin salt. This lake is used with iron salts for grey and black papers.

Coal-tar Dyes for Paper. The coal-tar colours are mostly soluble in water. If they were used for paper in the same way as for textiles, most of the dye would run off in the waste water from the machine wires. It is therefore generally necessary to precipitate the dye in an insoluble state upon the fibres of the paper. The size, however, constitutes a very suitable fixing medium for coal-tar dyes, whether it be made from rosin or wax.

The process of using direct cotton dyes is to size first, then to neutralise any excess of acid with the smallest possible quantity of soda, and then to add the dye. If the waste water is not properly clear, a little Glauber's salt may be added.

Dyeing Straw. The value of straw depends upon its length and toughness, as regards the dyer's point of view, and in both these respects rye straw probably holds first place. Straw intended for hats is obtained from grasses (usually wheat, which is largely cultivated for this purpose in Tuscany), grown solely from the point of view of straw production, and the plants are cut down before they are thoroughly ripe. The straw is then bleached in the sun on grass, exactly as linen is, with occasional sprinkling with water.

If chemical bleaching is resorted to, chlorine is the most reliable agent, although peroxide of hydrogen or sodium answers nearly as well. Chlorine is apt to tender the straw, especially if its action is unduly prolonged, or if the straw is not well rinsed afterwards. Sulphur bleaching is usually only temporary; the straw gradually returns to its original colour on exposure to air and light.

Preparing Straw for Dyeing. The preliminary treatment before dyeing consists in softening the fibre as far as possible, in order that the dye may penetrate. At the same time, the process removes all grease and other foreign bodies which would cause unlevel dyeing, as well as any soap which may still remain in the straw. This softening is usually effected by soaking first in a weak lye of carbonate of soda, and then in water, which may be used cold, warm, or boiling, according to circumstances.

Dyes for Straw. Dyewoods were formerly largely used, and they are still in current use, especially Brazil wood and logwood, but nine-tenths of all the straw dyeing nowadays is done with coal-tar dyes, with a preliminary bleaching if a light colour is desired. Coal-tar dyes should be chosen which are soluble both in alcohol and in water, as strong tinctures can be kept in stock and diluted with water as required for use. Direct cotton dyes are chiefly used, and the only requirements which have to be fulfilled are good colour and fair fastness to light.

As a general rule, mordanting, when necessary, has to be done at the boil, and the dyeing also. Although substantive dyeing of straw can, as a rule, be done without boiling, it is advisable to boil even with substantive dyes if great fastness is desired. The time of boiling varies with the mordant and the dye, and the mordanting and the dyeing may each take from half an hour to two hours, according to circumstances.

Dyeing Grass. Most grasses, like plant fibre in general, can be easily dyed in fairly durable tints, and all dyes which can be employed for wood or straw are suitable for grasses. Practically, nowadays, coal-tar colours are almost exclusively used, and most of them require no mordant. The extracts of cutch, curcuma, the redwoods and logwoods are, however, sometimes employed. Aniline dyes are kept by the grass dyer in concentrated solutions in water or spirit, which are diluted for use as required.

Dyeing Wood. Woodworkers rarely call their tinting processes dyeing, but rather staining, yet this is really superficial dyeing. Wood is dyed by brushing over it a solution of the dyestuff or by immersion in the dye-bath. The method may be preceded or followed by the application of a mordant, also in solution, applied hot or cold.

Wood chip and plaited straw, largely used for hats, are dyed very simply after the fashion of wood and straw respectively.

Dyeing Feathers. Before feathers can be dyed or bleached they must be cleaned from dirt and grease. This is done with warm soap and water. Rinse afterwards, first in warm and then in cold water. If preferred, the feathers can be cleaned with petroleum ether. The best bleaching agent, and one which does not injure the feather, is peroxide of hydrogen.

Any method of dyeing wool may be practised with feathers, the most usual dyes employed being the acid wool dyes, used with either sulphuric or acetic acid.

Very beautiful effects can be got by spraying the feathers with very minute drops from a sprayer. In this way different parts of a feather can be dyed different colours, and the various hues may be made to pass gradually into one another.

Dyeing Marble or Stone. The only way to colour marble or stone is to form the pigment in the stone by soaking the mass first in one solution, and then in another, which, by reacting chemically with the first, will produce the pigment desired. For instance, the successive use of potassium ferrocyanide and ferric chloride produces a blue. The use of solution is, however, attended with considerable practical difficulties. In close-grained stones, such as marble or hard limestone, penetra-

tion is difficult; and when the second solution is employed the first portions of pigment produced are near the surface of the stone and hinder the penetration of the second liquid. The secret is to employ liquids which produce pigments of great body, so that even a thin deposit just below the surface will give a sufficient colour.

Dyeing Horn. Horn is of the same substance as hair and finger-nails and the feathers and beaks of birds. Horn often requires bleaching before dyeing, on account of its strong natural colour in many cases. Peroxide of hydrogen seems to be the safest agent, and gives good results in careful hands.

Horn is dyed principally with coal-tar dyes, but dyewoods are also used to some extent. Black, though it can be dyed with anilines, is commonly got by the use of a warm solution of lead-salt, which forms lead sulphide with the sulphur of the horn.

Dyeing Ivory. Ivory has no chemical affinity for colouring matters. The permanence of any artificially produced colour upon ivory depends, therefore, on the protection of the bony matter into which the colour has penetrated to some extent. The processes employed in dyeing ivory are very similar to those used for bone, but there are two points of difference between bone and ivory. In the first place, ivory has far less organic matter in its constitution than bone, and, in the second, it is much denser and closer in texture than bone.

The first of these differences is in favour of the ivory dyer. He has no fatty constituents to contend with, and these are perhaps the worst difficulties in the way of getting level shades, and are very troublesome to remove. The second, however, cuts the other way. Successful dyeing of ivory depends little on the colouring matter used. Once a dye or a lake has been formed in the superficial layers of the mass, the ivory is coloured, and the colour is protected by the hard tissue of the bone. Penetration is therefore the main thing to be considered, and it will be evident that prolonged heating is usually required in dyeing such a closely knit substance as ivory.

Dyes for Ivory. Black is dyed on ivory with logwood and bichromate in two baths, and also with Nigrosine. Red is dyed with cochineal or Brazil wood. Another method is to boil scarlet wool in water, adding carbonate of potash at intervals until the dye is extracted. A little alum is then added, the solution is filtered, and the ivory is soaked to shade in the filtrate. The dye liquor must on no account be hot, but it is advisable to have it warm to save time. Picric acid or other soluble dye gives an excellent yellow, as does fustic on a tin mordant. Blues are dyed almost exclusively with anilines, which have practically ousted indigo-carmine from the ivory painter's palette. Methyl violet of various shades is used for violet. Greens are dyed with anilines, or by combining a yellow with a blue. Browns are dyed with anilines—such as Bismarck brown—and with cutch, but most of the ivory in this country is dyed with permanganate of potash, like wood. Most of the aniline browns can be shaded with red or other colours. Greys are got with baths which are the same as for black, but weaker.

Dyeing Vegetable Ivory. Vegetable ivory is the kernel or albumen of the seeds of a South American plant known as *Phytelephas macrocarpa*. It is always dyed with coal-tar colours, but the dyeing requires special experience, as the texture of the substance varies greatly with the age of the plant, the time of harvesting, and with the variations in the climate which occurred during the ripening of the fruit.

With the softer kinds of vegetable ivory a boiling with soap, followed by a good rinse, helps the absorption of the dye. Among the coal-tar colours used, nigrosine, picric acid, malachite green, methyl violet, and fuchsine are the most generally employed. Dyewoods are still used, however, to some extent, especially cutch and logwood.

Dyeing Bone. The dyeing of bone is a comparatively easy matter, as the coal-tar dyes penetrate it very readily, especially in hot solutions. In the great majority of cases no mordant is required. In the case of basic dyes the best mordant is tin-salt.

Dyeing Mother-of-Pearl. Mother-of-pearl is difficult to dye, on account of its hardness and close texture. It is usual to dye the finished object, such as a button, as it is impossible to dye through thick material without injuring the lustre. Articles made out of mother-of-pearl dyed before fashioning remain colourless at the edge. The rough and damaged places of the button or other article are first dyed; the dye goes most strongly into defective places, such as edges and cracks, so they become coloured before the lustrous surface is dyed. Mother-of-pearl is sensitive to the action of chemicals, and hence it is necessary to use very weak acid solutions, only lukewarm, and to let them act for the shortest possible time only.

Preparing Mother-of-Pearl for Dyeing. The first thing to be done is to free the mother-of-pearl from grease, and, if light colours are to be dyed, it must then be bleached.

The dyeing is done cold if possible, and it is better to dye for a long time in a warm bath than to hasten the process by greater heat. The greater the lustre of the mother-of-pearl, the harder it is to dye it. As the dye ought not to injure the lustre, time should only be allowed for the dye to get into fine cracks and between the layers, watching the process with a good magnifying glass.

In dyeing with acid dyes, make the dye to a paste wth acetic acid, adding to the bath a little oxalic acid. In dyeing with adjective dyes the result is usually dull. Mother-of-pearl is most easily coloured in spirit dyes, but the colours obtained are looser than the above.

Dyeing Celluloid. Celluloid is invariably dyed with coal-tar colours. For single colours the coal-tar dye is added to the materials in the process of incorporation. For dyeing patterns on celluloid, the finished article is coated with a resist, usually paraffin or beeswax, and the parts to be dyed are then laid bare. The whole article is then immersed in a cold solution of the dye. In a few cases heat may be required to make the dye penetrate, in which case a comparatively infusible resist, such as asphalt, is used. In no case, however, may too much heat be used, or the celluloid itself will be softened and lose its shape.

ARTHUR MORRIS

APPLIED CHEMISTRY CONCLUDED—END OF GROUP 6

The Commercial Side of Shipping. The Shore Departments. Marine Officers and Seamen. Training, Promotion, and Salaries.

THE MANAGEMENT OF SHIPS

THE supremacy of British shipping is due principally to the efficient working of its commercial side. Nearly one out of every two merchant ships afloat is under the Red Ensign, and this because shipping in this country is a highly organised commercial business, free in its working from control of any Government department. Subjected as it is to free competition of home and foreign rivals, every improvement in steam navigation has been eagerly taken advantage of, and every economical device to save fuel or the expenses of working a ship is tried, and, if proved effective, adopted by the British shipowner.

Management. Each of the large shipping companies has its own method of management, which has been evolved by its directors and managers from their experience and knowledge of the particular requirements of the services their vessels perform.

In the case of a large limited liability company, such as the principal liners belong to, there are, of course, the directors elected by the shareholders, and a manager or secretary appointed by the directors. In the case of privately owned firms, there are one or more managing partners, who look after the business. The directors or partners decide the general policy and the particular trades on which their vessels run; they fix rates of freight and passage money, sometimes in conference with other shipowners, more frequently in rivalry with them, and in deciding these matters the directors have available their managers or other experts, who are in most cases the heads of departments.

As methods of management vary, so does organisation; but, generally speaking, in the larger companies, at any rate, it would be somewhat as follows. First would come the manager or secretary — in some cases there are both — who, subject to the directors, is in charge of the whole business, and under whom come the heads of the various departments, who report to the manager and take their orders from him. The various departments, generally speaking, would be as follow.

Accounts and Statistics Department. This department is usually under charge of an accountant well versed in shipping matters, and is one of the most important branches. All the bookkeeping is done here. Voyage accounts are compiled, profit and loss sheets made up, statistics of all sorts brought out, and generally everything pertaining to figures and working costs are furnished at call from this department.

The shipowner of to-day can quote an intending charterer with a rate for his steamer at once by referring to his accounts department, and if he proposes to send his steamer on a particular voyage outside the ordinary run, he calls for and is furnished with a pro forma voyage account, which puts before him the probable voyage expenses and earnings, and he quotes his rates accordingly. An account of this kind would be drawn out something as under.

PRO FORMA VOYAGE ACCOUNT

s.s. ——— ——— tons gross ——— nett

Voyage from —— to —— —— days speed — knots.

DISBURSEMENTS		EARNINGS	
Wages of crew — days @ £	= £	In this column would appear the estimated earnings worked out as so many tons at the rates to be quoted.	
Port and light dues ..	= £		
Victualling — days @	=		
Loading and discharging — tons @	=		
Coal — per day = total tons @ —	—		
Depreciation on £ @ per cent.	=		
Insurance on £ @ per cent.	=		
Deck stores	=		
Engine stores	=		
Repairs and sundries	=		
Commission account	=		
Total	£	Total	£

Estimated profit on the voyage = £

Rate per ton per month = £

For steamers going through the Suez or Panama Canals, the canal dues would appear a big item on the disbursement side. The department has records showing the port dues, loading and discharging rates, and cost of coal at practically every commercial port. The depreciation and insurance are calculated on the book value of the steamer, and the average cost of many voyages gives the figures for deck and engine stores and repairs. In this department a practical knowledge of bookkeeping, of exchanges and figures generally, is necessary.

Marine and Engineering Department In small companies owning up to, say, half a dozen small steamers, or of one or two steamer companies, the masters and chief engineers of the vessels discuss with the owner the repairs, etc., required, and tenders for these are called for, and, as a rule, go to the cheapest offerer. Every big line, however, has a marine superintendent and a superintendent engineer (usually one of the most efficient and trusted commanders and chief engineers selected and taken ashore on the staff for the purpose), and they are responsible for all technical details connected with the deck and engine-room departments. In their hands, too, are left the selection and appointment of officers and engineers, as well as the promotion and transfer of the marine and engineering staffs. All questions of repairs, alterations, and so forth are dealt with in this department, and in the case of new vessels these officials give to the directors and managers the benefit of their technical advice.

These experts report on new inventions, and recommend their adoption or otherwise. When a new patent is adopted, close observation and record is made of its efficiency, and this department looks after all such records. The logs of the various steamers are entered up, their mileage and speed tabulated, their coal and oil consumption noted,

and in the case of excess over the usual average the captain and chief engineer are called on to explain the reason. In this way a check is kept on coal and oil expenditure, and careful and efficient marine and engineering superintendents mean much in the economical working of a big line. Besides the superintendents, the staff in this department is usually made up of one or more draughtsmen, an electrician, two or three junior clerks, and a few typists.

The young man entered in this department should apply himself to obtaining an accurate knowledge of the technical names of the different parts of a ship and her machinery.

Coal and Stores Department. On an estimate prepared for the year, this department will call for prices from contractors on their "suppliers list," and make contracts for the stores and coal required for the period fixed, usually six months to a year. In the stores department will be found samples of all the innumerable articles required by a modern ship, such as cordage, manilla and wire ropes, oils and paints, canvas, ironmongery, lamps, electroplate, cutlery, earthenware and glass, napery and linen, etc. These samples are carefully compared with the goods delivered by the various contractors, and any departure from sample is brought at once to the notice of the offending party.

When an "indent," as it is usually termed, meaning a requisition for stores sent in by the deck and engine departments, has been passed by the superintendent concerned, it is sent to the stores department. Here it is dissected, and orders sent for the stores indented to the various contractors.

A few junior clerks suffice for the work here, which is mostly routine, sending out orders and carefully checking suppliers' invoices with the ships' receipts and contracts. The responsible official in charge of this department is known generally as "the ship's husband," a happy description indeed.

Victualling Department. In close connection with the stores department is the victualling department. In some companies, in fact, they are one, and the stores do the victualling work as well. The shore purser or superintending steward is in charge here.

Into this department come the indents from the chief stewards of the various steamers, giving their requirements for provisions, meat, wines, etc., for the next voyage. These requirements are based, of course, on the number of passengers to be carried and on the length of the voyage. Striking figures have been published of the huge piles of perishable stores, of the mountains of bread, fish, fowls, meat, hams, eggs, and so forth, consumed on a voyage of one of the Atlantic greyhounds, but such statistics scarcely come within the scope of this article.

Regular and careful accounts are kept, and on the averages a daily victualling scale is fixed to which chief stewards have to conform. The picking and selection of the chief stewards is in the hands of the shore chief, and a good and careful chief ashore is usually reflected in the work of the men afloat.

General and Correspondence Department. This department has usually at its head the general manager or secretary. In the case of firms owning a few steamers it is run directly, very often, by the partners themselves. The staff is usually the largest in a shipping office, as all the general routine work of an ordinary business office is dealt with here. Here, also, is the cash department presided over by the cashier.

Passengers are booked, passage tickets issued, and inquiries answered. Sailing and advertisement cards usually adorn the walls, and cabin plans of the company's steamers lie on the counters.

The young man entering a shipping office usually begins here, being drafted to other departments later for experience, or according to his aptitude. He starts, as a rule, by copying letters and documents and fetching and carrying for his seniors. A knowledge of shorthand should be possessed by every youth, and if he is able to use a typewriter so much the better. Typists, however, are usually engaged as such and kept to that work. There is a call also for a knowledge of languages, particularly French and German. The development of intercourse with South America makes Spanish a useful acquisition, and Russian will be of immense service in the business of shipping in the coming generation.

Freight and Bills of Lading. This department looks after the engagement of freight, etc., and is usually divided into export and import sides. The export issues bills of lading for goods shipped from the home ports abroad, while the import department deals with the manifests and bills of lading for cargoes coming into the home ports.

In these days of keen competition the shipowner has to hustle to secure his freights. He does not wait for the shipper to come to him, but looks after the shipper. In London a representative of this department will be a member of the "Baltic." In Liverpool and Glasgow business is done on the "Exchange," and in Newcastle on the "Quayside," as the shipping exchange there is called locally. The "Baltic" in London is a palatial edifice in St. Mary Axe, replete with all comforts for its clients, and this may be termed the hub of the freight market in London. Here shippers and shipowners have full information as to freights and rates, and here they do their deals.

The freight department watches the trade journals, notes all big orders placed for railway materials for abroad, and then puts freights forward to the firms concerned. Here the early bird often catches the freight worm, and canvassers with a keen eye for business and an attractive manner are invaluable.

The freight being engaged, arrangements are made for shipment by a particular steamer. It is sent alongside by rail or barge, as is cheapest or most convenient, and is at the ship's risk from the time it leaves the quay wall or barge till clear of the ship's tackle when landed at the port of destination. As cargo comes on board, it is "tallied"—that is, a note is taken of the cargo, whether it is case, package, etc., and the "mark." A receipt is given, and this receipt, being presented to the freight department along with a bill of lading (which is usually in triplicate), is signed by the department "for the master," and it is then the merchant's title to the goods described. Only on production of this bill of lading, or an indemnity freeing the shipowner of all liability, will the goods be delivered to the consignee.

Particular trades, such as the Black Sea, Mediterranean, etc., have their own particular form of bill of lading, and most of the large companies have also a special form bearing their house flag or distinguishing emblem.

The Bill of Lading. The bill of lading gives the names of the shipper and the consignee, the name of the steamer and master, the port of shipment and the destination, the number of packages, and the date. On the margin is detailed the number of packages, their contents, and marks. Freight is payable on delivery of the

bill of lading "ship lost or not lost," and a recital is given of all the liabilities from which the shipowner frees himself, including "the act of God, the King's enemies, robbers by land and sea, restraint of princes, rulers, or people"; and such commonplace things as "strikes or stoppages of labour."

The shipowner has a lien on goods shipped for his freight. He is held responsible for loss or damage or short delivery, provided he has granted a "clean" bill of lading—this is a B/L without any remark as to the cargo being damaged or in bad condition.

All packages, as a rule, bear a mark, not an address, and all large shippers have their own particular mark, many of them well known in trade to the general public. Underneath the mark is the port of destination, and the package is usually numbered as well.

Sample marks are given below.

A mate's receipt granted on delivery to the ship and on which the bill of lading is made out would read something like this:

s.s.———

Date

Received in good order and condition on board the s.s.———, ——— Master, the undernoted goods.

New York. ABC $ 1/3 3 *cases hardware.*

(sgd.) J. SMITH,
2/ mate.

A considerable number of clerks are employed in the freight department. Bills of lading for large ports have each, as a rule, a separate desk assigned to them, and the clerks employed check the bills of lading produced by the shipper with the mate's receipts, and make out the freight notes. This requires careful calculations. Goods are shipped on weight or measurement at the option of the steamer, and one freight note will involve many calculations of weight and measurement rates of freight.

The young man coming to this department needs all his wits about him. He must be careful and methodical, with a quick and accurate knowledge of figures. Here outside work is regarded as the "plum," and the ambition of the smart man is to get on the "Baltic," or shipping exchange, and do the outside freight work.

There is also usually an expert attached to this department skilled in estimating damage and settling losses. The outside public have little knowledge how many and various are the claims made by shippers for damaged or missing cargo. A smart, tactful man can save his employers thousands of pounds a year in the working of the "claims" department.

Insurance Department. In all large shipping companies there is an insurance department. It is usually in charge of an experienced man well versed in marine insurance law and customs. Many of the large shipping companies insure their steamers in a special fund of their own, and find it pays them to do so. The premiums, ranging as a rule from 4 per cent. to 6 per cent., are charged against each steamer's earnings, and credited to the "insurance fund." Against the insurance fund all claims for damage and losses are debited. The larger companies insure the cargo carried by their own steamers, and the baggage of passengers. In the case of companies where the insurance is done "outside," the risks are taken by Lloyd's and the other great maritime insurance companies.

On the outbreak of the European War (1914), the Government made arrangements with Lloyd's and other insurance companies to reinsure 80 per cent. of all risks to shipping insured by them.

Lloyd's. In marine insurance matters Lloyd's overshadows every other concern. It is also the great organisation for the collection and distribution of marine intelligence. All round our coasts and in every part of the world Lloyd's agents advise the movements of the ships of all nations, and not one vessel in ten bound to ports in the United Kingdom arrives as her terminal port without being "reported at Lloyd's."

Lloyd's, too, has a "Captains' Register," showing the service of every master in the mercantile marine, and in this connection much valuable and confidential information of great value to underwriters is available for the benefit and guidance of members and subscribers.

An inquiry office is also maintained by Lloyd's where relatives of the crew or passengers may obtain without cost information regarding the movements of the vessel in which they are interested.

It is scarcely within the province of this article, and space forbids any particular description of the business of Lloyd's, or the clauses which make up its marine policies, but to anyone engaged in shipping a knowledge of the abbreviations used is not only useful but necessary. Hereunder is a table of common abbreviations.

H.C.	Held covered.
S.A.	Subject to approval.
N.R.	No risk.
U.K. or C. ..	United Kingdom or Continent.
Cont. H. and H.	Continent between Havre and Hamburg.
Cont. B. and H.	Continent between Brest and Hamburg.
F.O.	For orders.
O.P.	Open policy.
F.C. and S. ..	Free of capture and seizure.
D.C.	Deviation Clause.
T.L.O.	Total loss only.
F.A.A. ..	Free of all average.
F.G.A. ..	Foreign general average.
Y.A.R.	York Antwerp rules.
R.I.	Reinsurance.
R.D.C.	Running down Clause.
C.C.	Continuation Clause.
D.C.	Detention Clause.
L.C.	Label Clause (Bottled goods).
F.P.A.	Free of particular average.
P.A.	Particular average.
G.A.	General average.
P.L.	Partial loss.
S.L.	Salvage loss.
C.T.L.	Constructive total loss.
T.L.	Total loss.
W.P.	Without prejudice.
Wd.	Warranted.
W.A.	With average.
P.P.I.	Policy proof of interest.
A.R.	Against all risks.
W.O.B. ..	Washing overboard.

Lloyd's has a close connection indeed with the commercial side of shipping, and from the "A1 at Lloyd's," which describes the highest class granted to a merchant ship when she starts her first voyage, till her disappearance through loss or breaking up Lloyd's never loses sight of her.

In Lloyd's Register appears the name of every steamer and sailing ship afloat, showing the owner's name, the name of the builder, the classification, tonnage, and her general measurements, as well as her official number and port of registry.

The Merchant Shipping Act. This Act defines the duties and responsibilities of owners, masters, and crews, as well as the machinery of the

Board of Trade Mercantile Marine Offices (known to Merchant Jack as "the Shipping Office") and others authorised to deal with ships and seamen. The Act of 1894, in its 744 sections, amended and modified by the Merchant Shipping Acts Amendment Act, 1906, and other Acts, provides for practically every point likely to arise in connection with the owning or management of British vessels.

The first section of the Act gives the qualifications necessary for owning British ships, wherein it is laid down that a ship shall not be deemed to be a British ship unless owned wholly by persons of the following description, namely: (*a*) Natural-born British subjects; (*b*) persons naturalised by or in pursuance of an Act of Parliament or ordinance in a British possession; (*c*) Persons made denizens by letter of denisation, and (*d*) Bodies corporate established under and subject to the laws of some part of the King's dominions, and having their principal place of business in those dominions. It is under the last qualification, of course, that the great majority of British shipping is registered.

The second section of the Act provides for the registry of every British ship, and accordingly the first proceeding of an owner of a British vessel is to register her, and the procedure as to this is laid down in Sections 4 to 20 of the Act.

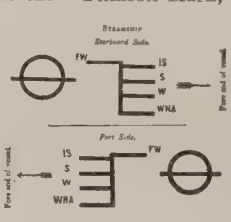
Registering a Ship. When a new steamer is built she is measured for tonnage by a Board of Trade surveyor, and the measurements so ascertained are embodied by the shipbuilder in a document known as "The Builder's Certificate," which is handed to the owner, who, on the figures given therein, makes out his "declaration of ownership." This document gives the name of the owners, their principal place of business, and the number of shares in the vessel. A vessel is divided into 64 shares, so that a sole owner would be described as owning 64/64th shares. This document, then duly signed before a shipping master or a commissioner of oaths, is handed in along with the builder's certificate and the certificate of the master, to the registrar of shipping at the port where the vessel is to be registered. The registrar then allots the vessel her "official number." This number having been carved on the main beam of the vessel, and her port of registry painted on the stern, and a carving note signed by a surveyor to that effect being furnished, the registrar grants the "certificate of registry." This is the vessel's most important document. It is at once her birth certificate and passport; without it she cannot obtain clearance from any port, and failure to produce it would render a vessel liable to seizure as an ownerless and suspicious craft. The certificate of registry shows the vessel's name, official number, and port of registry, gives full details of her measurement and tonnage, and the name of her owners and her master.

Selling a Ship. In the purchase or sale of a British ship there is little formality, no need for a lawyer, and the process is simplicity itself, a steamer valued at a million pounds being more easily disposed of than land or a house worth a hundred. The seller signs and seals a document known as a *bill of sale*, which gives the name of the steamer sold, and other particulars from her certificate of registry, the names of the sellers and buyers, and this document being handed over to the registrar of shipping at the steamer's port of registry, the old register is closed, and a certificate granted to the new purchaser, and the business is done. The bill of sale in its wording is a quaint survival of the days when the merchant ship was armed, as in its wording it transfers the shares "in the ship above particularly described, and in her boats, guns, ammunition, small arms, and appurtenances." The modern vessel, however, as a rule, has neither guns, ammunition, nor small arms, but the form survives. If a British vessel is lost, taken by the enemy, or sold to foreigners, notice of the fact must be given, under penalty, to the registrar, who thereupon closes the vessel's register, except in so far as any unsatisfied mortgages are concerned. The owner is bound to give up the ship's certificate of registry if the steamer is sold to foreigners, or if it is saved in the event of wreck.

Legal Rights of the Crew. The Acts provide and lay down conditions for the engagement of a crew, and every member of the crew must have the agreement read and explained to him by the shipping master or his deputy. Facilities are granted to seamen to complain of any grievance, and pains and penalties are enacted to protect the seamen from imposition of any kind. Even his food is provided to scale laid down in his agreement, and his quarters are certified to accommodate the number of crew.

"Jack" nowadays is quite competent to look after himself, and demand what he terms his "rights," and his trade union—the Seamen's and Firemen's Union—is vigilant in this matter.

In the agreement with the crew the freeboard of the steamer is given. This is a change from the bad old days of the "coffin ships," and the fixing of a safe freeboard was one of the points so strenuously fought for by the "seaman's friend," the late Samuel Plimsoll, M.P. The load-line cut and painted on the side of every British ship is known universally as the "Plimsoll Mark," and is shown below.



The letters shown on the load-line mark are FW, fresh water; the load draft of the vessel in fresh water, IS, Indian summer; S, summer; W, winter; and WNA, winter North Atlantic. The British load-line regulations are accepted by nearly all foreign Governments.

Part II. of the Act deals with masters and seamen, and makes provision for apprentices being carried. It also provides for the examination and grant of certificates to competent men, and states the conditions for the issue of licences to supply seamen, and for their engagement. The rating of A.B.—that is to say, able-bodied seaman—is granted only when the seaman has served at sea for three years.

Elaborate instructions are laid down regarding the discharge of seamen, payment of wages, seamen's money order and savings banks, and the property of deceased seamen. By law, everyone on a ship's articles is a "seaman," and when a seaman dies on board a British ship his wages and effects must be handed over by the master of the ship to the Board of Trade, who transmit these through a shipping office to the relatives of the deceased. Provision is made as to discipline, and for an official log, wherein is entered the record of any offences, births, deaths, etc. To be logged, to a seaman means much the same as a police conviction to a landsman.

The records of the service of all persons who serve in ships is kept at the office of the Registrar-General of Shipping and Seamen. The appointments of the Registrar-General and his staff are made by the Board of Trade, which, with the consent of the Treasury, regulates their salary and allowances. In this office are collected all the statistics as to

seamen, etc., also records of deaths, births, and marriages on board any British ship.

Provisions for Passengers. Part III. of the Act deals with passenger and emigrant ships, regulates their equipment and fixes the number of passengers or emigrants they may carry. As to emigrants, the Act fixes that as regards steerage passengers no ship may carry more than :

(*a*) If the ship is a sailing ship, one adult to 33 tons of the ship's registered tonnage ; and

(*b*) If the ship is a steamship, one adult to every 20 tons of the ship's registered tonnage.

A ship must not carry passengers, cabin or steerage, on more than one deck below the waterline. Provision is made for the survey of passenger steamers, for the general equipment, for the maintenance of order, for the supply and inspection of provisions, water, and medical stores, and so forth.

Sundry Regulations. Part IV. of the Act deals with fishing-boats, and relates to " all fishing-boats and to the whole fishing service."

Part V. is headed " Safety," and deals with regulations for the prevention of collisions at sea, regulates the lights to be carried and exhibited, the fog-signals to be used, and the steering and sailing rules to be observed. It also deals with the load-line, the loading of timber, and carriage of grain, and unseaworthy ships.

This part of the Act is now greatly modified by the Merchant Shipping (Convention) Act, 1914. All vessels carrying 50 persons or more are required to be fitted with radiotelegraphic apparatus capable of transmitting signals at least 100 sea-miles.

Part VI. sets up the machinery for special shipping inquiries and courts ; and Part VII. deals with delivery of goods and lien for freight.

Part VIII. defines the liabilities of shipowners, which the Act declares to be—

(1) In respect of loss of life or personal injury, either alone or together, with loss of, or damage to, vessels, goods, merchandise, or other things, an aggregate amount not exceeding £15 for each ton of the ship's register ; and

(2) In respect of loss of, or damage to, vessels, goods, merchandise, or other things, whether there be in addition loss of life or personal injury or not, an aggregate amount not exceeding £8 for each ton of the ship's tonnage.

Part IX. deals with wreck and salvage, the registration of marine-store dealers, the appointments of Receivers of Wrecks, etc. ; Part X. fixes pilotage, and applied to all ships, British and foreign, but this has been repealed by Pilotage Act, 1913, under which pilotage of vessels is now regulated. Part XI. deals with lighthouses and the levying of light dues, which under present arrangements are all borne by the shipowner, and which he justly claims should, in the United Kingdom, as elsewhere, be borne by the State.

Part XII. refers to the Mercantile Marine Fund, which deals with all charges in respect to fees for survey of ships, fees paid at the various shipping offices, etc. It is modified by Mercantile Marine Fund Act, 1898.

Part XIII. deals with the methods of legal procedure ; and Part XIV. is supplemental, and defines the general control of the Board of Trade, the appointment of surveyors and inspectors, and the power of Colonial legislatures in regard to shipping.

The Mercantile Marine as a Profession. The mercantile marine offers an excellent career to the man of steadiness and intelligence. There are three departments open to the youth who decides to follow the sea : (*a*) as a deck officer ; (*b*) as an engineer ; and (*c*) the saloon department, as purser or steward.

To qualify as a *deck officer*, the youth must serve an apprenticeship, and he may do this in several ways. He may be sent by his parents to the training ships Worcester or Conway, for the two years' school course there. This will cost parents about £60 a year, but the boy gets a splendid training in seamanship and navigation, as well as an excellent general education. These two years in the Worcester or Conway are allowed to count as one year's sea service, but to be qualified to sit for examination for a second mate's certificate the youth must now serve three years at sea ; this he can put in as an apprentice in a sailing ship or as cadet or midshipman in a steamer. There is no difficulty in getting a youth apprenticed or appointed as a cadet. The large steamship companies, such as the British India Line, the New Zealand Shipping Company, Shaw Savill & Albion Co., Bucknall Bros., the Gulf Line, now carry cadets or apprentices, the premium ranging from 30 to 100 guineas, which is returned to the boys as wages. These companies endeavour to give the cadets a knowledge of seamanship, navigation, and the general duties of a navigating officer, but the steamer-trained officer is seldom up to the standard of the youth trained in a sailing ship.

A young man may also qualify by serving before the mast, as boy and O.S. (ordinary seaman), and many excellent captains and officers have begun their sea profession in the forecastle.

Nautical Examinations. After completion of the four years sea time the youth goes up for the Board of Trade examination for a second mate's certificate, and this obtained, he is fully qualified as a junior officer in the mercantile marine. The supply of officers is less than the demand, and the young man should experience no difficulty in obtaining a berth as fourth officer in one of the " liner " companies. His pay will run from £5 to £6 a month, with " all found "—that is to say, assuming a youth goes to sea between 15 and 16 years of age, by the time he is 20 he is in a position to keep himself. His first step is to third officer, when he is in charge of a watch ; this step he should get in from a year to eighteen months in most large companies, and he now puts in his time for chief mate's certificate. This obtained, he is eligible for promotion to second officer, which rank he should reach after three to five years' service. Then he passes for master, and obtains afterwards, if he can, an extra master's certificate as the result of a further and special examination. Promotion to chief officer reaches him after seven to ten years, depending on the company he serves, and he reaches command after fifteen to twenty years' service. His pay as chief officer will run from £12 to £18 a month, and as commander from £20 to £60 a month, and in some exceptional lines and services he may get £800 to £1,000 a year.

Promotion. Promotion to command goes by seniority, tempered by selection, and the smart and efficient chief officer, as a rule, gets his command before men senior to him, who have not shown themselves so zealous for their employers' interests.

The large shipping companies, as a rule, engage only young officers, and train them themselves. These juniors receive promotion to the higher grades as vacancies occur, and only in exceptional cases is an officer or commander brought in over the heads of men in the service.

Application should be made in writing to the manager or marine superintendent of the line

selected, and the letter should be accompanied by copies of testimonials. This, as a rule, brings a reply, asking the applicant to call for a personal interview, and the interview being satisfactory, and his papers in order, an appointment follows.

Marine Engineers. To qualify for a marine engineer, an apprenticeship of at least five years must be served in an engineer's establishment—a marine engineer's shop for preference. Here the youth should begin at the age of 15 or 16, so that he will finish his time when he is between 20 and 21 years of age. During his apprenticeship the youth who desires to get on will attend evening technical classes in drawing, machine construction, and kindred subjects, all of which he will find most helpful when he goes up for his Board of Trade examinations, and throughout his career. The great marine shops are on the Clyde, in Scotland, and on the Tyne and the East Coast of England, and Belfast in Ireland. As a rule, no premium is charged, and in fact the majority of engineers regard the premium apprentice with suspicion, considering he is likely to have too much false dignity to learn his business properly. Wages are generally paid the apprentice, say 4s. a week the first year, rising by 1s. or 2s. a week each year of the five he serves. His apprenticeship completed, the young man should send in his application to the superintending engineer of three or four of the big companies. He should state clearly where he served his time, what special certificate he holds, his age, and send a copy of his apprenticeship certificate. When appointed, it may be as tenth engineer, or even as fifth or fourth, depending on the size and power of the steamer to which he is posted.

His ambition is now to get his time in as a watch-keeping engineer, to enable him to obtain his second and chief engineer's certificate. Usually the second's examination is passed after about eighteen months to two years' sea service, and a chief's certificate is obtained after four to five years' sea service. A longer period of service is required where the steamer is a home-trade vessel than where it is a foreign-going steamer. Promotion depends on the line in which the engineer serves. He should be third after three to four years, second after seven to eight years, and chief engineer after 15 years' service. The pay of a junior engineer begins at £7 to £8 a month, with "all found"; as third he will receive £10 to £12, as second £14 to £18, and as chief £20 to £40, depending on the number of years' service. The chief engineer earns a bonus on savings in coal and oil consumption.

Pursers and Stewards. Only the large passenger boats carry pursers, and their duties vary according to the line on which employed. In some of the companies he is a clerk pure and simple, doing the captain's correspondence, writing out manifests, passenger lists, etc.; while in other lines he combines these duties with the general oversight of the saloon department. Generally speaking, however, the duties of purser and steward are separate. The purser usually secures his appointment through the nomination of a director, and puts in a few months or a year or so in the office of the company before he is sent afloat. There is nothing particularly exacting in the duties of this office, and a young man of average intelligence can easily acquire a knowledge of them. Vacancies, as a rule, seldom occur in the big lines. Pay will run from £6 to £12 a month,

Pursers are carried by river and pleasure steamers during the summer months, and here the duties are more concerned with the collection and issue of passengers' tickets. There are many applicants, and the pay is small—from 10s. to 30s. a week, The young man who desires to go to sea as a steward must begin at the very bottom of the ladder, and, as a rule, he learns his experience in a hard school. The river and pleasure steamers, or in the steerage department of an Atlantic liner, would give an opening, and experience gained, the efficient steward works his way upward to chief by his own efforts. The pay of assistant stewards is nominal, and they depend on tips from passengers to a great extent. A chief steward will be paid from £8 to £12 a month. A knowledge of catering for passengers is essential to the efficient steward, and second only to this is tact.

Royal Naval Reserve. The officer or engineer desirous of serving his country or ambitious of social advantages, joins the Royal Naval Reserve. The qualifications necessary, aside from the fact that the applicant for a commission must be a British subject, are as under :

For midshipmen: a two years' course in one of the mercantile marine training ships, or a year at sea on board a first-class British ship. For sub-lieutenant : service as first mate of a first-class British steamship of at least 1,500 tons, or a sailing ship of 1,000 tons, and the possession of a master's certificate. Second and third mates are eligible provided that they have served for not less than six years at sea, excluding their time as apprentice, and for lieutenant, service in command of a steamer of 1,500 tons or a sailing ship of 1,000 tons is necessary for not less than one year.

A senior engineer must hold a first-class engineer's certificate, and have not less than 10 years' sea service, including three years as chief of a steamer of not less than 500 nominal horse-power.

An engineer must hold a first-class certificate and have seven years' sea service, including one year's service as chief engineer of a steamer of 200 nominal horse-power, or as second of a steamer of 500 horse-power, and an assistant-engineer must hold a first or second-class certificate and have served at least one year in a steamer as a certificated engineer.

Qualifying Drills. It is necessary for the lieutenant, sub-lieutenant and midshipman, to put in qualifying drills at stated periods, and such officers may volunteer to go through a twelvemonths' course of training in H.M. fleet. This course completed satisfactorily, officers are granted certificates, and become entitled to the following annual allowances: Lieutenants, £25 a year; sub-lieutenants, £20 a year; midshipmen, £10 a year.

Officers of the reserve when called out for training receive the same pay and allowances as officers of the corresponding rank in the Royal Navy, and while on service they are treated in the same manner in every respect.

Besides the experience, and the social polish which a training in the Navy undoubtedly gives, and considering that an officer can live on his pay while serving, the annual allowance granted certainly makes it worth while for a merchant service officer to serve in the Reserve.

The tonnage of the mercantile marine under the Red Ensign grows and increases with the years, and the shrewd brains which control it are as capable now as ever, and if only the youth of the country, gentle and simple, would do their share, and come forward as they did in the years gone by, as officers and seamen, there seems no reason why the preponderance of our lead in shipping matters should not be maintained.

W. CAMPBELL GALBRAITH

TRANSIT CONCLUDED—END OF GROUP 8

The Characteristics of Good and Cheap Bindings. Sewing with Cords and Tapes. Covering and Tooling. The Attractive Trade of Book-publishing.

BOOKBINDING & PUBLISHING

BOOKBINDING

By F. Sangorski and G. Sutcliffe

Before entering upon the technical details of bookbinding, it will be advisible to give an explanation of the composition of a book, and of the sizes in which books are made. A book is printed on sheets, and the size of these sheets and the number of times which they are folded decide the size of the volume. The sheets are generally used in the following sizes: Foolscap, 17 in. by 13½ in.; medium, 24 in. by 19 in.; crown, 20 in. by 15 in.; royal, 25 in. by 20 in.; post, 19¼ in. by 15½ in.; super-royal, 27 in. by 21 in.; demy, 22½ in. by 17½ in.; imperial, 30 in. by 22 in.

When the sheets are folded once they make a folio-sized volume; twice, quarto (4to); three times, octavo (8vo); four times, 16mo; and five times, 32mo.

A book is said to be a "crown 8vo," or a "demy 8vo," when sheets of "crown" or "demy" size are folded three times. When folded, each sheet is called a *section*, and consists of the number of "leaves" into which the sheet has been folded—an 8vo volume having, for instance, eight leaves in each section—each leaf consisting of two pages. The top edge of a book is termed the *head*, the bottom edge the *tail*, and the front edge the *fore-edge*.

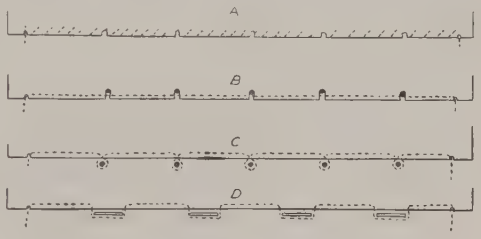
Bookbinding is divided into three branches—sewing, forwarding, and finishing. With sewing are included all the processes which ultimately end in the sewing of the sections together. Forwarding comprises the processes which complete the binding of the book; and finishing, the processes which result in the decoration of the binding.

Machine Binding. The demand for inexpensive binding, brought about by the increase in cheap literature, has led to the introduction of machinery into the craft. With publishers' cloth bindings, the processes from beginning to end are carried out by machinery. But though by this means cheap work is produced, it is usually at the expense of the quality of the binding. If the best work be required, it must be done entirely by hand, with just the aid of such appliances as have been in use almost since the invention of bookbinding. As, however, there are now so many books that are not worth the expenditure necessary for the best binding, the use of machinery is compulsory; but a method should be adopted that will allow the use of machinery without seriously damaging the binding. The essential requirements of a soundly constructed binding are: (1) All sections broken at the back should be mended, and all loose leaves and plates secured to the sections with a guard; (2) the book should be sewn on at least five cords or four tapes, which should project from the backs of the sections; (3) the boards should be firmly attached to the book, all the cords and tapes being interlaced into the board; (4) the leather should be directly attached to the back; and (5) all materials used should be of sound quality, uninjured during manufacture.

With the exception of the cheapest work—cloth binding—there is no reason why all these requirements should not be met; but owing to the demand for a showy exterior at a low price they are not usually considered by the modern binder.

Modern Cheap Binding. Usually, if the sections are broken at the back, the practice is to cut off a piece of the back, thus making the section into single leaves, and to sew these leaves together in the manner shown in **1** A. This is called overcasting, but a section so sewn together will always be liable to break away from the rest of the book and will never open freely.

With sewing, the cords, instead of projecting from the back of the book, are sunk into the sections, saw cuts being made in the back, the level back thus obtained enabling the book to be backed by machinery. But the sewing is not nearly



1. SEWING BOOK SECTIONS

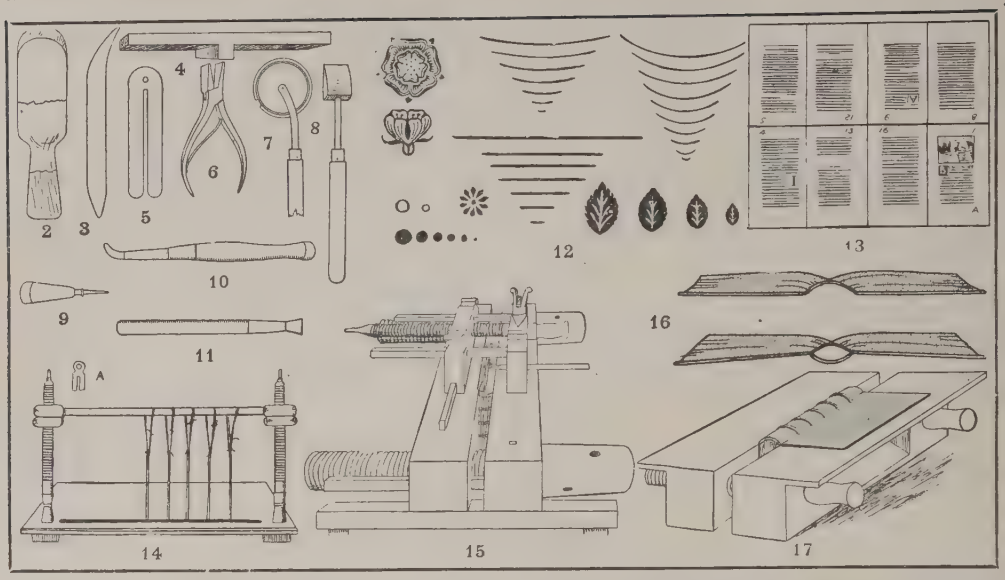
as secure, for instead of the thread passing round the cords as seen in **1** C, it merely passes across them as in **1** B; and if broken, the probability is that the section will come out.

All books that are to be backed by machine should be sewn on tapes. The sewing is secure [**1** D], and the tape does not make sufficient projection to prevent the machine being used.

Too thin a cord is generally used, and often two are cut off, and only the remainder interlaced into the board.

The sinking of the cords prevents the book opening well, and to get over this to some extent, the leather is not attached to the back. A hollow casing made of brown paper is glued on, and the leather attached to this. The leather is attached to the boards, and the boards to the book merely by the cords laced into them; consequently, all the strain of opening and shutting the book is placed on these cords, and they often break away, the book then coming away from its cover. If the leather is stuck directly on the back, it assists the cords in attaching the cover to the book [**16**]. The cords have been sunk into the book, but as the public have been accustomed to see the projections on the back made by the cords, false ones are stuck on.

Good Inexpensive Binding. For the best binding the book should be sewn on cords, and meet all the requirements we have mentioned. If the question of expense has to be considered, the decoration should first be discarded. After that, leather being needed principally on the back and corners, only these portions need be covered with leather, and the remainder with a



2–17. TOOLS AND APPLIANCES USED IN BOOKBINDING

2. Paring-knife 3. Folder 4. Knocking-down iron 5. Trindle 6. Band-nipper 7. Fillet 8. Polishing-iron 9. Bodkin 10. Agate burnisher 11. Bloodstone burnisher 12. Ornaments 13. Sheets for folding 14. Standing press *A*. Sewing-key 15. Press, with plough and pin 16. Correct and ordinary binding 17. Finishing press

less expensive material. This is what is called "half binding." For a further reduction the book should be sewn on tapes, and by this means an inexpensive and durable binding can be obtained.

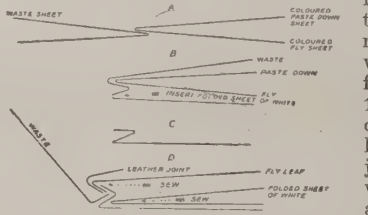
Following is a list of tools and appliances necessary: Standing press; sewing press [**14**]; sewing keys [**14** A]; bloodstone burnisher [**11**]; agate burnisher [**10**]; square; band stick; tenon saw; trindles [**5**]; bodkin [**9**]; pressing boards; cutting boards; backing boards; nickel pressing plates; set of letters, dots, rings, punches, leaves, flowers, gouges, straight lines, and other ornaments [**12**]; press with plough and pin [**15**]; paring stone; paring knife [**2**]; hammer; folders [**3**]; glue pot; compasses; band nippers [**6**]; knocking-down iron [**4**]; gold cushion and knife; pressing tins; millboard shears; finishing press [**17**]; finishing stove; fillet [**7**]; polishing iron [**8**].

If the book is received in sheets, these sheets have to be folded. We will suppose they are to be folded three times, making an 8vo volume. The sheets are lettered alphabetically in one of the corners [**13**]; these are called *signatures*. Usually, J, V, and W are omitted. The sheets are placed in alphabetical order with the signatures in the right-hand bottom corner. The first sheet is turned over, so that the signature comes face downwards on the left-hand bottom corner, and is folded in half from right to left, care being taken that the printing corresponds. A folder [**3**] is used to crease the fold. Pages 2 and 3 will now face. The top right-hand corner is then folded, and pages 12 and 13 will face. Folding in half, so that 8 and 9 face, completes the folding of the first section. The remainder are folded in a similar manner.

Washing Stained Sheets. Any stained sheets are washed in the following manner: An ounce of permanganate of potash is dissolved in a quart of slightly warmed water. The stained sheets are put into this solution for about an hour, causing them to turn a dark brown colour; they are then taken out and washed in clean water. One ounce of sulphurous acid is put into a pint of water, and the sheets washed in this until all the stains have disappeared. They are again washed in clean water, and hung up on lines to dry. When dry, they are sized by dipping them into a solution of one ounce of isinglass dissolved in a quart of water, applying heat and again hanging up to dry. If the sheets are too white when taken out of the acid, the size is slightly tinted with tea, coffee, or any other staining fluid.

Making Endpapers. When all the sections have been made sound and the plates guarded on, endpapers are made. They are attached in the following way. Two folded sheets of white paper, similar in tone to that on which the book is printed, and a folded sheet of coloured paper, are required. The coloured sheet is pasted on to one of the white sheets as shown in **18** A. When dry, the white leaf marked "waste sheet" is folded over one coloured leaf, and the other white leaf folded back over the remaining coloured one, as in **18** B. The other folded sheet of white is then inserted where marked, and the end paper is sewn on to the book through this. The waste sheet is for the purpose of protecting the end papers during the binding, and is torn out when the endpapers are finally pasted down.

If a leather joint is used, the endpapers would be made up in the following manner. A white sheet is folded as in **18** C, and the coloured fly-leaf, leather joint, and waste sheet, are pasted on to this as in **18** D. A folded sheet of white is inserted, thus completing the endpaper, which is sewn on in the two places marked in **18** D. The endpapers are placed in their positions



18. ENDPAPERS

at either end of the book and then tins covered with paper are placed between every three or four sections and the book placed in the standing press for about twelve hours.

The positions of the cords or tapes on which the book is to be sewn are then *marked up* on the back. The book is knocked up square at the head and held in the lying press between a pair of pressing boards and the back is divided into six divisions. Five of these are made equal and the tail one slightly longer. On the five points thick pencil lines are drawn across the back. If tapes are used for sewing four are usually sufficient and two lines are marked for each tape. A slight saw cut is then made at the head and tail about half an inch away from the edge, and the book is ready for sewing.

Sewing the Sections Together. The book is sewn on five cords; the number sometimes varies with the size of the book, but five is the most usual; the thickness of the cords also varies according to the size of the volume. Five loops are made of ordinary string over the crossbar of the press; these are called *lay cords*, and are used repeatedly. To these loops are attached the cords on which the book is to be sewn, which are then passed down through the slit in the bed of the frame and fastened by means of keys [**14**].

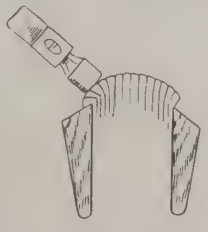
The book is laid down on the bed of the press with the back against the cords, which are moved into position so that they correspond with the lines marked on the back of the book. The cords are then tightened by screwing up the crossbar.

The endpaper is first sewn, the needle with thread or silk being passed into the section at the head and round each cord in turn and brought out at the tail [**1** C]. The first sheet is then sewn from tail to head in the same way, and the silk is tied to the loose end hanging from the endpaper. Another section is sewn on and the needle is inserted between the previous sections and catches up the silk that joins them; this is called a *kettle stitch*. The remaining sections and endpaper are sewn on in the same way, the silk being fastened off at the last kettle stitch with a double knot. The cords are loosened, by lowering the crossbar, and are cut off about 3 in. from the book; the loose ends are then frayed out with a bodkin.

If the book is to be sewn on tapes, the tapes are set up on the sewing frame as with cords. The sewing is done as described above, with the exception that, owing to the width of the tape, the thread passes out and back into the section again at different points instead of passing out and in at the same point as with cord sewing [**1** D].

Gluing Up, Rounding and Backing. The book is placed in the press with a piece of millboard on each side, and the back is glued. When the glue has set the book is laid down on its side and half of the back is rounded over with a hammer, it is then turned over and the other half rounded.

Backing is sharply emphasising part of the swelling caused by the thread used in sewing, by compressing the book near the back and beating the back of the sections, one over the other, making a sharp ridge against which the cover will lie. Placed between a pair of backing boards with the back projecting slightly above the boards, the book is lowered into the lying press. With a hammer the sections are then beaten one over the other, starting from the centre and going over equally on either side. The two outside sections are well beaten over the backing boards, for this makes a sharp groove for the boards to fit [**19**].



19. BACKING

Preparing and Attaching the Boards. The best material for the boards is millboard owing to its toughness and thin substance. Two pieces are cut with the millboard shears about a quarter of an inch larger all round than the book. The edges that are to go to the back of the book are then cut smooth in the lying press with the plough. The boards are screwed up in the press with the amount that has to be cut off projecting above the bed of the press. The knife in the plough travels backwards and forwards level with the bed of the press, and whatever projects is cut off.

The boards are then each lined on one side with a piece of white paper pasted on. Two other pieces of paper, double the size, are pasted and the boards covered with these on both sides. The extra lining of paper on one side will cause the board to warp that way, and this side will be placed against the book to counteract the pull of the leather which will ultimately be pasted on the other side of the cover.

The boards when dry are cut to the size required, with the press and plough, and are then attached to the book. One board is laid in position on the book and a line is drawn on the board from tail to head about half an inch from the back. Lines are then drawn from the cords to this line. On these cross lines small V-shaped pieces are cut out of the boards to allow the cords to sink in level when laced, and holes are punched with a bodkin at the points where the lines meet. The boards are then turned over and holes are punched about half an inch from the previous ones. To attach the boards the slips are pasted and passed through the holes first made and then back through the other holes. They are then drawn tight, tapped with the hammer to fix them, and the ends cut off level with the boards.

If the book is sewn on tapes the selvedge of the tape is cut off and the tape can then be frayed out and interlaced, like a cord. When both boards are attached the book is put in the lying press, with the back projecting slightly; it is then pasted to moisten the glue on the surface, which is scraped off with a folder. The cords are nipped up and straightened with the band-nippers, tins are put on both sides of the boards, well up to the groove, and the book is left in the standing press, tightly screwed up, for about twelve hours. The knocking-down iron is then screwed up in the press, and the slips hammered down until they are impressed level with the board.

To cut the top edge the book is screwed up in the lying press with the back to the worker, the front board being lowered just the distance required for the "square," and the edge is cut with the plough [**15**]. The tail is next cut in the same manner.

For cutting the fore-edge the edge has first to be made flat by inserting trindles [**5**] between the book and the boards across the back. A cutting board is placed on each side and held in place while the trindles are removed. The book is then lowered, with the boards hanging down, into the press and the edge cut with the plough.

Gilding Edges. The back is knocked flat, and a cutting board placed on either side of the leaves, level with the fore-edge, and the book is placed in the press. The edge is scraped and finely sandpapered. A paste, made of powdered red chalk and water, is applied to the edge with a sponge and polished with a hard brush. The edge is then painted with a preparation of the white of an egg,

beaten up and diluted with water, called *glaire*. The gold leaf is cut into strips the width of the edge and applied to the edge with a soft flat brush. The book is left to dry and the edge finally burnished with a flat bloodstone burnisher. The other edges are gilt in a similar manner. The edges can also be stained. Water stains answer the purpose, and are applied to the edge with a soft brush, the edges being afterwards burnished with an agate burnisher.

Headbanding. Headbanding is the stitching on the head and tail of a strip of vellum, gut, or cord, to make a similar projection from the back as is made by the boards projecting beyond the edges of the book. As a book is usually pulled out of the bookshelf by the headband, it is important that this should be firmly attached to the book, and one that is made on the book is far preferable to one bought ready-made and stuck on.

The boards are lowered level with the edge of the book held in the lying press or plough, and a needle, threaded with silk, is passed into the edge and out at the back below the kettle stitch. Half the silk is drawn through, and then the needle is again inserted and drawn out. The silk now has made a loop into which a strip of vellum, slightly narrower than the "squares," and a little longer than the width of the book, is placed. The silk is drawn tight and a pin inserted in the edge at the left-hand side, behind the vellum, to keep it in position. The needle end of the silk is brought over the vellum and the other end crosses it and goes behind. This end is then brought over and is crossed by the needle end. The headbanding is continued in the same manner, being fastened down to the book about every quarter-inch. To do this when the needle end is at the back, it is brought over the vellum and inserted into the book and out at the back, and the headband is then proceeded with as above. To finish it off, the needle end is inserted into the book twice, and the other end then pressed behind, and both are cut off, leaving short ends, which are frayed out and pasted down to the back. The ends of the vellum are then cut off.

This kind of headband would be too expensive for the cheaper bindings. In their place the leather at head and tail can be turned over a piece of string when covering.

Leather for Bindings. Various kinds of skins are used in bookbinding, chief among them being those of sheep, oxen, calves, goats, and pigs. *Sheep skins* are cheap, and, when not subjected to hard wear, last well. Those classes of skins tanned in India, and known as "Persians," both sheep and goat, have little durability. *Calf skin*, although capable of receiving a beautiful finish, does not wear well. *Ox hide* has to be reduced so much in substance to be fit for binding books that the greater part of its strength is lost. *Goat skins* furnish "Morocco" leather of several kinds. Of these, the finest is that of the Cape of Good Hope, known when finished as "Levant Cape Goat"; it has a bold, natural grain, and is perhaps the most beautiful leather for bookbinding. *Pig skin* is very durable, and is best adapted for large work. A leather which has great beauty and strength is made from the Greenland seal, but much depends on its preparation.

In cutting out the leather a piece of paper is first cut to the size of the leather required, and the leather is then cut to the size of the paper. The leather requires thinning (termed *paring*) in several places: (1) where it is turned in, to enable it to turn neatly over the edges of the boards; (2) where it will go over the back, to allow the cords to be sharply emphasised; and (3) where it will go in the joints, to enable the boards to open freely.

As there is a double thickness of leather where it is turned in on the back, it is pared especially thin there. The cover is marked in pencil to show where the paring is required, and is laid on a smooth stone and pared with a knife to the necessary degree of thinness.

Covering the Book. Before covering, the edges of the book are "capped up" to prevent damage from the paste used in the process. Two pieces of thin celluloid are placed on either side of the book itself, which is then completely covered up with paper. Small pieces are next cut from the back corners of the boards to allow for the leather being turned in there.

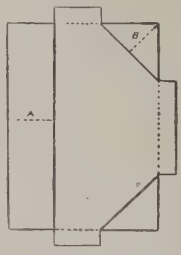
The leather is well pasted, the book, closed, is laid down in the place marked for it, and the remainder of the cover is drawn over the back and the other side. The book is then stood on its fore-edge, and the leather pressed from the back towards the fore-edge. The leather is slightly damped on the back with water, and the bands are nipped up with band-nippers. The cover is next smoothed on the sides and the leather is turned in over the fore-edges of the boards and smoothed down with the folder; finally, the cover is turned in at the head and tail.

At the corners the leather meets at an angle of 45°, and the surplus is cut off with scissors just above the board, and one edge of the leather is lapped over the other. A piece of thread is now tied tightly along the joints passing across the head and tail, and pressing the leather in where the back corners of the board have been cut away.

The bands are again nipped up, and the leather between the bands well rubbed down with a band stick. Finally, the cover is sponged over with water to remove any paste that may have got on the book, and, with a piece of paper on each side, the book is placed between a pair of pressing boards and left for at least twelve hours. When the leather is set, though not actually dry, it is trimmed on the inside of each board.

Half Binding. If the book is to be half bound, the processes are just the same up to covering, and then only the back, about one-third of the sides, and the corners are covered with leather.

The proportion between the back, corners, and the remainder of the sides can be seen in 20. The dotted lines A and B should be of the same length. When dry, the leather is trimmed straight at the back and corners, and the material for the side is cut out. This is usually either paper, cloth, or buckram. It is cut to the shape shown in 20, and then glued on, the edges being turned in over the edge of the boards. With the cheaper bindings, the corners are sometimes omitted, and it is then called a quarter binding.



20. HALF BINDING

Pasting Down Endpapers. The waste sheet is torn out and any pieces that remain in the joint are removed with a knife. The inside edge of the board is then sandpapered or scraped with a knife to remove any glue or paste that may have adhered. The width of the margin of the leather is then taken with a pair of dividers, the pasting-down paper drawn over the board, and the measurement marked off all round on the paper. A tin is then placed on the book and the paper laid down on this, cut round with a knife, and pasted down on the

board. It is rubbed down through a piece of waste paper, particular attention being paid to the joint.

Finishing and Decorating. *Tooling* is the usual method adopted for the decoration of leather bindings. It is divided into two classes —"gold tooling" and "blind tooling." Finishing tools are made in either brass or steel, and have surfaces cut in the forms of lines, dots, or engraved with pattern [12]. For long lines a fillet is used. This is a wheel with an edge cut to the thickness of the line required [7].

If an elaborate pattern is required, a thin, tough paper is used for a working pattern, slightly pasted at the corners, and placed in position on the cover. Then all the tools of which the pattern is made up are heated and stamped in through the paper. A pad of wet cotton-wool is kept close by, and the tools are used when they just cease to hiss on the wool. They are held in the right hand, and when striking, the tool is guided into its place with the thumbnail of the left hand.

If the pattern is to be in blind tooling, the leather is damped and the tools again stamped in. The heated tool coming in contact with the damp leather makes a rich, dark impression.

If the pattern is to be in gold, the leather is washed with vinegar, and when dry, the impressions are painted with glaire, very slightly diluted with vinegar. When the glaire is dry, the gold leaf is cut into pieces of a convenient size to lay on, the leather is slightly greased with a piece of cotton-wool and vaseline, and the gold is picked up with another piece of wool and laid on the pattern and firmly pressed down. The pattern should be clearly seen through the gold, and the tools are now stamped in again. When all the pattern has been impressed, the surplus gold is rubbed off, leaving just the gilded impressions of the tools.

The book is then placed in the press, with tins on the inside of the boards, and nickel plates on the outside, and slight pressure is applied; this causes the boards to close properly, and completes the binding of the book.

PUBLISHING

The publishing of books is admittedly one of the most attractive trades to which a young man can turn his attention. Even old men are tempted to set up as publishers by the general notion that it is about the most lucrative business in which one may engage. This latter is, now, a mistaken idea, whatever reason there may have been for it in the past, and certainly a review of the fortunes made in publishing would go far to support the proposition that it is a paying business. The shrewd Scotsman who founded the house of Murray in the year 1768 had been in the Navy, and was induced to turn publisher because he observed "many blockheads" were then "making fortunes" in that very pleasant occupation. Modern competition has long since made it impossible for any but the most resourceful of men to succeed in the world of publishing, and only a few businesses, which exist very largely on their old reputations, can be conducted on the easy methods of half a century ago. There is undoubtedly no room for blockheads today. In point of fact, after newspaper publishing, there are few businesses in which one can more speedily get rid of a considerable fortune than in book-publishing. To secure any substantial success, a large capital investment is absolutely essential, and this none the less when it is associated with brains and intimate knowledge of the trade.

Value of an "All-round" Experience. There is, of course, a "royal road" to publishing as to most other trades, although our moralisers may deny this. But few of us are in the position to follow the royal road, and have, instead, to take the toilsome way which, in the end, is likely to be more solidly successful, and may, on the whole, by honest endeavour, be made as pleasant. If we cannot, by paying a substantial fee to some publisher for the privilege of receiving an insight into all his departments—as so many Germans used to do in London—we must needs begin at the bottom of the ladder. Naturally, the earlier one enters the trade the better. We know one of the most successful of the younger publishers who practically went through every department, beginning as a shop-lad in a large wholesale firm of distributors, with his mind constantly set on becoming a book-publisher. As he had realised his ambition before he was thirty, it will be seen that, given sufficient pertinacity and resource, even the humble shop-lad may look forward to seeing his name as the imprint of thousands of books some day.

In all the leading provincial cities there are large firms of wholesale dealers in any one of which invaluable experience may be obtained, provided always that one enters their service early enough—say, from fourteen to sixteen years of age. By passing through the various departments in a large wholesale house, the Town Department, the Country, the Postal, the Stock, and other departments, a thorough knowledge of a most important side of the publishing business may be obtained. One might come somewhat later to the wholesale trade, if one had previously secured some experience in a retail booksellers' [see BOOKSELLING, page 4453], and, indeed, this would be a wise course to pursue.

The Producing of Books. But after everything has been learned, both in the wholesale and retail, there would still remain the most important knowledge of all to be acquired—namely, the manufacture of books. The bookseller and the wholesaler only come in after the publisher has done his work. It is by no means usual that one man should have experience in every detail of the trade from the producing to the selling of books, and in every publishing house in the country there are many employees who have served for years, and are content to serve, in some particular department without acquiring a general knowledge of the trade. Indeed, such men necessarily form a majority of those engaged in the business, but it is not from such that successful publishers are made, and nothing is more fatal to promotion than remaining too long in any one department.

Before turning to the consideration of the actual business of a publisher, we should point out that most valuable experience can be obtained by engaging as traveller with a wholesale house. Of course, every publishing firm of any standing employs a number of travellers from whose ranks many of our most successful publishers have risen. We have preferred to mention the great wholesale houses first, as these are not confined to London, whereas, excepting a few notable firms in Edinburgh and Glasgow, there are practically no important publishing houses outside of London. The provincial youth has thus to turn his attention—in the first place, at least—to the wholesale distributors and the large booksellers, who very often do a small amount of original publishing.

London is essentially the Mecca of publishing, and the young man who is ambitious of becoming a

publisher will do well if he can secure an engagement with a London publisher when he is about twenty years of age.

The Young Publisher's Progress. Assuming that he is determined to be no mere employee in a department, but has set his mind on a managerial post at least, we shall suppose him to have had, first of all, a reasonable knowledge of English literature [see LITERATURE], and if he gives evidence of any literary taste and judgment, he will not find it difficult, after he has spent some time in the Costing Department, where he will have become familiar with the cost of producing a book and the various qualities of material used, in getting into the Production Department, the scope of which varies greatly in accordance with the importance of the firm. Here the duties consist of keeping account of all accepted MSS., arranging with the printers for specimen pages, and estimating the size of books, deciding upon the style of title-pages, bindings, general get-up, and proof reading. It is, in a word, the department in which all the practical detail of production occurs, from which the MS. of a book is handed to the printer, and from which the first completed book is handed over to the manager. In the smaller firms this department is concerned also with drawing up the spring and autumn catalogues, but in the large houses that important part of a publisher's business usually falls to the lot of the Publicity Department.

It will be gathered from our qualifying references that it is very difficult to speak of the publishing trade in general terms. There are many publishers earning a good livelihood who employ no more than half-a-dozen assistants, and unite in themselves all the different departments we have mentioned. In fact, it is no bad plan for a young man to attach himself to one of these smaller publishers, as the variety of work which will fall to his share every day will result in his acquiring a very good knowledge of the trade more speedily than it could be acquired in one of the larger firms.

The Work of the "Literary Adviser." The office routine of a large publishing house is, of course, very much the same as that of any other business, but the young man who has shown sufficient literary aptitude to be placed in the Production Department is fairly certain to be employed sooner or later in the reading of MSS., and in consultation with the manager preliminary to the acceptance of a work. The "literary adviser" used to be a somewhat mysterious person who read all the MSS. received, and supplied reports as to their literary qualities and the likelihood of their success. He was sometimes himself a distinguished novelist, who thus eked out some extra income by giving what was very frequently the most misleading advice. This old-fashioned type of adviser is disappearing. The successful publisher of to-day depends hardly at all upon the unsolicited MSS. he receives. They are read and reported on as of old, but his reader, if he himself does not do the work, is more likely to be some alert person with the real journalist's knowledge of what is calculated to interest the public, and it will be found that he or the publisher himself will be the first to think of most of the books they will publish. As a matter of fact, the ideal publisher, or literary adviser, is essentially an ideal editor. The editor of a successful magazine has a certain public, or perhaps several publics, in mind when he sits down to plan out his next number. In order to secure an attractive programme, he will ask a certain number of distinguished writers each to contribute a story of a certain kind and a given length. He will arrange so many articles to suit this section or that section of his readers, and he will ask certain writers to prepare them. He will then decide how many pages each is to occupy, including illustrations, and will carefully choose the artist who can best do the different kinds of pictures he requires. Hence, although he may receive 200 MSS. per week, he will seldom retain more than two, and nothing but the fear of missing a good article by an unknown writer induces him to wade through the MSS. Now, if for stories and articles we substitute novels and books of biography, travel, and general literature, the publisher is engaged in precisely the same work as the editor. This indicates that one may come to publishing through editing; but, of course, for such a one the SELF-EDUCATOR is hardly likely to be a guide.

"A Genius for Publishing." It is unnecessary here to dwell upon such technical details as the arrangement of a book, the various sizes of paper, types, illustrations, printing, and book-binding. All these matters are dealt with in other parts of the present course, and with them the beginner in book production must necessarily and speedily familiarise himself. In the little space that remains to us we must confine ourselves to the general aspects of publishing, and need we say that after every possible tittle of information touching the practical side of the business has been acquired, if the intending publisher is not gifted with the peculiar acumen that makes the successful editor and the prosperous publisher, he may have studied and prepared for the work in vain? There is some touch of genius in knowing just what is likely to meet the tastes of the many different sections of the public, and without this all the technical knowledge in the world will avail nothing. Every day of our life we see books being published which we know cannot possibly succeed. Sometimes this is the bad judgment of the publisher; again, it may be the foolishness of the vain writer, who has paid some publisher to issue the work, but publishers who do this never rank high in the profession.

Risky Publishing and Safe. Not very well can we lay down any rule as to the amount of capital that is required to engage in publishing. Everything will depend upon one's personal requirements and how soon a return for one's money will be expected. This, however, can be said, that cheap publishing requires by far the largest amount of capital. That is to say, to deal largely in attractive editions of non-copyright books at cheap prices involves a much greater risk than the publishing of original works in general literature, in editions of, say, one thousand copies, at good prices, from six shillings upwards; and if the possibilities of the more expensive publishing are not quite so great, the money invested is far safer and likely to produce a substantial return. Novels, and fiction of all kinds, involve a much greater element of risk than works of biography and travel; but it is an axiom of the trade that educational and technical books are of all the most desirable to publish, as they supply a demand that can be easily gauged, and if at all well done, cannot easily fail to be profitable.

PRINTING CONCLUDED—END OF GROUP 9

From Cadet to Admiral. Entrance Examination. Naval Colleges. Course of Training. Special Entry Cadets. Pay and Promotion. The Royal Marines.

THE NAVAL OFFICER

We have shown how a seaman may rise in the Navy from a second-class boy to commissioned rank; we shall now proceed to explain how a boy more favoured with Fortune's blessings rises from midshipman to Admiral of the Fleet. It will be observed that we deal in this section only with the executive branch of the Service, the Paymaster branch being dealt with in the Civil Service group on page 2573.

Efficiency of the Naval Officer. Today the cry of the Navy, as in every other profession, is for the life-trained officer, for there is so much to learn in our complicated floating boxes of machinery that to know even a part means a life study. For a man who is to lead men, also, the training in the habit of obedience and discipline cannot begin too early. In the case of other Services, charges are sometimes levelled that the training methods are inefficient, and that the living is extravagant. This, however, cannot be said of the Navy, where the keynote of naval education is thoroughness, and where economy of living is the watchword. From the moment a boy joins the training college as a naval cadet he is taught that strict attention to work is the only avenue to promotion; and his allowance of pocket-money would compare badly with that of a public school boy of his own age. After reaching the rank of lieutenant a young man can live fairly comfortably on his pay.

It must be understood that at present the representatives of two systems of education are working side by side in the Navy. Under the old system boys entered for whatever branch of the Service they fancied—executive, engineers, or Royal Marines. The result was a race of specialists—each man excellent in his own department, but knowing very little about the work of other branches of the Service. To remedy this state of things a new system has been introduced to produce a type of officer with a more comprehensive knowledge and wider sympathies. The age of entry is now between 13 years 4 months and 13 years 8 months, so that today a boy must decide practically on leaving his preparatory school that he desires to enter the Navy. The new scheme, however, is still to some extent upon its trial, and will probably be modified again as the outcome of the lessons of the great war.

The Preliminary Examination. The training begins at Osborne College. To be admitted, a boy must be of pure European descent, and the son of natural-born British subjects, or of parents naturalised in the United Kingdom. An application for appointment should be addressed to the assistant private secretary of the First Lord of the Admiralty, and should not be made before the boy is 12½ years old. On receiving a notice from the First Lord, the candidate is required to present himself before a committee, not for an examination of his book knowledge, but so that the committee may have an opportunity of judging from his conversation and manner what sort of a boy he is, and whether he is likely to make a good officer when he is grown up. The candidate is required to produce a certificate of birth (or its equivalent), a certificate of good conduct from the master of the school or schools at which he has been educated for the previous two years, and proofs of good health and freedom from constitutional disease or hereditary taint of any kind. A severe medical inquiry has to be faced, and then the qualifying examination, which embraces the following subjects:

English: Dictation, simple composition, and reproduction of the gist of a passage read twice by the examiner.

History and Geography: The whole outline, with special reference to the British Empire.

Mathematics: Arithmetic (simple), including decimals, fractions, mensuration of area and capacity, money, proportion, etc. Algebra, up to simple and simultaneous equations. Practical geometry (angles and construction of angles, squares, parallelograms, and division of straight lines into equal parts). Theoretical geometry (angles at a point, parallel lines, triangles and other rectilinear figures, areas, and loci).

French or German: Simple examination, with great stress on the *vivâ voce* part.

Latin: Easy passages for translation, English-Latin and Latin-English, and simple grammatical questions.

Specimen examination papers can be obtained.

Cost of Training. This examination successfully passed, the lads have to present themselves in uniform at Portsmouth Dockyard on the appointed day, and are taken across to Osborne by a Government launch. Here the foundation of their life-work is laid.

Beyond the cost of the kit, which consists of bed-linen and towels as well as clothes, the cost to the parent is at the rate of £75 per annum in three (advance) instalments of £25. Over and above this, to cover the miscellaneous expenses, such as washing, instruments, books, sports, and pocket-money, another £8 per term should be expended. In a few cases the Admiralty allow the sons of officers in the Army, Navy, or Civil Servants under the Admiralty to enter at a reduced payment of £40 a year.

Osborne College. The Naval School at Osborne is organised on the lines of the best public schools, special attention being directed to fit the cadet for his career, not only as a skilful seaman, but also as an officer and a gentleman. Examinations are held at the end of every term; and should a cadet fail to satisfy the Lords of the Admiralty his parents may be asked to withdraw him at any time. A declaration of willingness to do this has to be signed at the time of the boy's joining, together with a declaration of willingness that the boy shall enter that branch of the Service for which he may seem to be best fitted, whether engineering, Marine, or general executive. At Osborne a splendid workshop has been fitted up,

and the cadets spend quite half of their time in practical and theoretical work connected with engineering or in studies closely bearing upon it. Physical education and seamanship are also well looked after.

Dartmouth College. After two years the cadet passes on to Dartmouth College for another two years, to complete his preliminary studies. The course of this four years' training includes the study of mathematics, mechanics, heat and electricity, the theory and practice of engineering; English and French composition and literature; history and geography, navigation, and the elements of seamanship; religious knowledge; and physical education. In his first summer at Dartmouth he and his colleagues pay a visit to Devonport in a torpedo-boat destroyer, which they have to drive and steer. On leaving Dartmouth he goes to a training cruiser for more practical instruction in navigation, seamanship, and engineering than can be obtained ashore. Until he reaches the rank of acting sub-lieutenant his parents are required to make him an allowance of £50 a year, and thereafter £20 a year until he becomes a sub-lieutenant.

Midshipman. At the end of six months on the training cruiser he is drafted with a batch of youngsters of his own seniority to a sea-going ship as midshipman. This, however, does not mean that his education is complete. True, he is no longer under a civilian instructor, but he devotes his whole time to learning his professional duties under one or other of the officers, about one-third of his days being spent in the engineering section. On completing three years' service as a midshipman a serious examination has to be passed for acting sub-lieutenant in seamanship and practical engineering. He attends the next examination in navigation and general subjects, and he attends short courses on gunnery, torpedo work, and pilotage at the depots, each of which is followed by an examination on the work studied in the course. Those who show aptitude and special ability are then allowed to go through a further and more comprehensive course, lasting six months, at Greenwich Naval College, which fits them for specialising in any particular branch.

The sub-lieutenants who do not qualify for the extra course are immediately sent to sea, and are joined by the Greenwich students at the completion of their course. Sub-lieutenants must serve at sea for at least one year before being promoted to lieutenant, and must obtain from their captain a certificate that they are efficient in the duties of officers of the watch.

"Special Entry" Cadets. Although the Osborne and Dartmouth course remains the normal means of entry into the Royal Navy, a supplementary scheme has been introduced in consequence of the war, enabling at least sixty lads yearly to become cadets between the ages of 17½ and 18½, and to reach the rank of midshipman after only 1½ years' training. These "special entry" candidates are selected precisely like the rest, save for the higher age limits and an entrance examination which is correspondingly severe. On passing the latter they undergo a course of instruction which lasts for eighteen months, being quartered meanwhile on board a cruiser, but spending part of their working time on shore. On completing this course they join the fleet as midshipmen, and, after less than two years in that rating, are eligible for promotion to that of acting sub-lieutenant. The result of these shortened terms of service is that a "special entry" cadet

RATE OF PAY OF ALL RANKS OF OFFICERS IN THE NAVY

Rank.	Per Annum.	One Day.	Special Remarks.
	£ s. d.	£ s. d.	
Admiral of the Fleet	2190 0 0	6 0 0	With table money varying between £547 10s. and £1642, according to station and the amount of entertaining required.
Admiral	1825 0 0	5 0 0	
Vice-Admiral	1460 0 0	4 0 0	
Rear-Admiral	1095 0 0	3 0 0	
Commodore (1st Class)	1095 0 0	3 0 0	
Captain of the Fleet	1095 0 0	3 0 0	
Captain	410 12 6 to 602 5 0	1 2 6 to 1 13 0	With Command money varying from £91 5s. per annum to £328 10s., according to rank and circumstances.
Commander	401 10 0	1 2 0	Command money when commanding a ship, or on special service, £45 12s. 6d. to £91 5s.
Lieutenant	182 10 0 to 310 5 0	0 10 0 to 0 17 0	Command money, £45 12s. 6d. to £68 8s. 9d. Senior Lieutenant of a ship, £27 7s. 6d. to £45 12s. 6d. Gunnery or Torpedo Lieutenants, £27 7s. 6d. to £73. Navigating Lieutenant, £45 12s. 6d. to £73.
Lieutenant promoted from Gunner or Bo'sun, etc.	237 5 0 to 273 15 0	0 13 0 to 0 15 0	According to seniority. Extra allowances for specialists.
Sub-lieutenant	91 5 0	0 5 0	Command money, £36 10s. per annum.
Midshipman	31 18 9	0 1 9	
Naval Cadet	18 5 0	0 1 0	
Engineer Rear Admiral	1095 0 0	3 0 0	
Engineer Captain	638 15 0 to 730 0 0	1 15 0 to 2 0 0	
„ Commander	438 0 0 to 602 5 0	1 4 0 to 1 13 0	
Engineer Lieut.	182 10 0 to 365 0 0	0 10 0 to 1 0 0	According to seniority. Extra pay if in charge of engines, £18 5s. to £91 5s.
„ Sub-lieutenant	136 17 6	0 7 6	
„ Lieutenant promoted from warrant rank	264 12 6 to 301 2 6	0 14 6 to 0 16 6	According to seniority.
Chaplain or Instructor	219 0 0 to 401 10 0	0 12 0 to 1 2 0	
Inspector-General of Hospitals	1300 0 0	—	
Fleet Surgeon	492 15 0 to 638 15 0	1 7 0 to 1 15 0	
Staff Surgeon	365 0 0 to 456 5 0	1 0 0 to 1 5 0	
Surgeon	255 10 0 to 328 10 0	0 14 0 to 0 18 0	
FLYING CORPS:			
Commanding Officer	800 0 0	—	With quarters.
Squadron Commander	456 5 0	1 5 0	With 8s. a day Flying Pay.
Flight Commander	310 5 0	0 17 0	
Flying Officer	219 0 0	0 12 0	

NOTE.—Allowance for all Officers of Submarine Service, 6s. a day.

THE TRAINING OF THE NAVAL OFFICER

THE NAVAL COLLEGE, DARTMOUTH

IN THE CARPENTER'S SHOP

INSTRUCTION AT THE LATHE

A PARADE OF NAVAL CADETS

IN THE MACHINE SHOP

LEARNING HOW TO SPLICE ROPES

The photographs on this page are by Messrs. S. Cribb and Frith

becomes a lieutenant only about a year later than one who enters by the usual route. From this point the same career is open to officers who have entered by either method. Cadets who enter under the special regulations must pay for their own outfit, and require a private allowance of £50 a year until

PAY OF OFFICERS, ROYAL MARINE ARTILLERY.

	One Year. £ s. d.	One Day. £ s. d.
Colonel Commandant	730 0 0	2 0 0
Major	293 10 5 to 337 12 6	0 16 1 to 0 18 6
Captain	220 10 5 to 284 7 11	0 12 1 to 0 15 7
Lieutenant	115 11 8 to 135 7 1	0 6 4 to 0 7 5
Second Lieutenant	95 16 3	0 5 3
Quartermaster	173 7 6 to 282 17 6	0 9 0 to 0 15 6

NOTE.—In R.M.L.I. the rates are slightly less in all ranks.

they become acting sub-lieutenants, and then of £20 a year for the time (usually only about two months) that they remain in this rank; but no college fee need be paid for their training.

Lieutenants. Under the new scheme of education, the dividing line between general and special training is crossed about a year after promotion to a lieutenancy. At this point the lads, who have all been trained under much the same system, are now apportioned to the branch for which they are most fitted, and the most capable among them become specialists in engineering, in gunnery, torpedo, or navigation, being denoted by the letters E, G, T, and N, while some go to the Marines, whom we shall call M. Each undergoes further training to equip him for his particular duties—the gunnery officer going to Portsmouth, the navigation expert to Greenwich Naval College, and so on. Lieutenants (M) go to one of the Marine divisions to learn their special military work. The rest become general service lieutenants, popularly known as "salt-horse lieutenants," who are available specially for watch-keeping, discipline, and seamanship.

Of these specialists a few of the best are allowed a further course of instruction to fit them for a higher grade of lieutenant, which, for the sake of clearness, will be called G 2, T 2, and E 2. For these the higher course lasts for one or two years. Of the general service lieutenants a few are selected for instructional purposes, and undergo a short course to fit them for their work. Not only is promotion speedier for the specialist officer than for his less brilliant or less hard-working colleagues of the "salt-horse" class, but he earns higher pay or extra allowances in each rank.

Branches of the Service. Now it has been explained how the lads trained together in the same system as far as the rank of lieutenant have been broken up into three main divisions—engineers, Marines, and what we shall call, for want of a better term, general executive officers, which divisions have been subdivided into specialists and non-specialists. It remains to be shown what these young men will do with their careers. Will the specialists continue as specialists to the end of their days, or do they foster the hope of one day commanding a fleet?—for it is still open to the engineer to revert to the main channel and go through the ordinary course of promotion.

In exceptional cases, it is possible for the lieutenant (E 2) to revert, but it is most unusual, and indeed, undesirable, for he is throwing away his special education and his chance of quicker promotion. He will therefore look to the engineer branch to provide his fortune, and he will rise in the ordinary course to commander (E 2), captain (E 2). And although he will go to sea from time to time to keep in touch with modern practical engineering, the Admiralty will be glad to make use of his services ashore and in the higher ranks of the dockyard advisers. The Marine lieutenant, in some cases, will revert to the general executive, and be appointed commander in his proper turn; for not only today is he the musketry officer, but he can also take his turn in watchkeeping and the general duties of the ship. On the other hand, he may qualify for commander (M), and then revert to captain in command of a ship. A third possibility, of which a few will avail themselves, is to continue discharging the duties of Marine commander, and look for promotion in the Marines through the ranks of captain (M), major (M), and colonel to general.

The Ladder of Promotion. For the rest, the general service lieutenants, there is a long, weary wait for their next step. After five years' service in the rank the officer has to pass an examination in naval law, court-martial, naval history, strategy and tactics, besides the examination in the general professional subjects. In due course his turn for promotion comes, and he is promoted to commander, probably in ten or twelve years. It must not be supposed that the time has been monotonously spent. He has been changing from ship to ship, has been in torpedo-boats, destroyers, cruisers, and battleships, and has served at home and abroad. He has attended qualifying and re-qualifying courses, and has every year been learning something of the management of ships, of guns, and of men. So that at about the age of thirty-five he is a man of wide knowledge and experience, besides having passed about twenty severe examinations. Another four to six years as commander should see him promoted to captain, if he is fortunate, though still he has not completed his education, but must go to Greenwich to learn the higher teachings of strategy. In the end he is promoted at last to admiral after eleven to fifteen years in command of ships.

The Royal Marines. We have seen how this, like any other branch of the naval service, may be chosen by the ex-cadet from Osborne and Dartmouth who shows sufficient ability. But a certain number of commissions in the Royal Marines are awarded to candidates from outside the naval colleges. Competitive examinations similar to those for entering Woolwich are held among youths between 17 and 19 who have satisfied the interview committee. Successful competitors are sent to the Greenwich Naval College, and take special courses in gunnery, torpedo work, and military duties, and are also required to serve afloat. After a period of nearly five years' training, they are subjected to a final examination, on passing which they rank as lieutenants in the Royal Marines. They usually remain in that corps, although a transfer is possible for them, as for the ex-Dartmouth officer who has taken up the Marines' duties, from the "sea-soldiers" to the purely naval branch.

Exhibitions and Demonstrations. Sampling Schemes. Railway, Omnibus, and Tramway-car Advertising. Showcards and Posters.

MISCELLANEOUS ADVERTISING

NEWSPAPER and poster advertising brings the name of an article or product before the public, but there are various forms of publicity that go farther than this, and bring the actual product either before the immediate notice or into the very hands of the people. Such methods of direct advertising are in great and growing favour among manufacturers and shopkeepers, and they certainly get as near to ensuring sales as it is possible for any advertising to do. These methods place the article right into the hands or the homes of the people; and if the public do not then become customers, it is because the article is not good enough, is not wanted, or is not sufficiently better than a rival article that is well established. Advertising can go no farther than this.

Exhibitions. Among these forms of publicity, the first to be considered is that which is effected by means of exhibitions. Here, under favourable conditions and in circumstances that certainly help to attract and to hold the attention of the spectators, goods are displayed with even greater advantage than in a shop window. Every trick of colour and artificial lighting may be utilised; the visitors come for no other reason than to look at things and to be interested in them, and one has opportunities of speaking to people and commending one's goods to them that do not occur on so extensive a scale in any shop or store.

Various Kinds of Exhibitions. Of course, exhibitions are of various classes and kinds. Some are intended frankly and primarily as places of amusement, to which the public can go for entertainment. Others are intended to be educational; and while there may be attractions of the purely entertaining class, yet instruction is the prime object of the exhibition. Then there are trade exhibitions the object of which is to attract the shopkeeper or merchant, and to get from him on the spot an order for the goods he sees. The public, of course, visit these shows to a limited extent, but it is the trader who is primarily concerned. The big foreign expositions must not be neglected, these, of course, being of interest only to firms that do or wish to do an export business. At the opposite extreme are the small local exhibitions, scarcely heard of outside their own immediate neighbourhoods, but which are nevertheless often of great use from the advertising point of view to the manufacturer, merchant, and shopkeeper. Still another kind of exhibition, known as a Trade Syndicate Exhibition, combines to a certain extent the amusement, the instruction, and the trade benefits of the larger exhibitions referred to.

Trade Exhibitions. Trade exhibitions are a recognised feature of the business life of the country, and many manufacturing firms spend a great deal of their appropriation in making use of these exhibitions. There are various firms who make it their business to organise and finance trade exhibitions; and while this is sometimes done quite independently of all trade organisations, the usual method is to secure the active patronage of the local trade association.

In consultation with the association, a date is arranged and a hall taken, and it is then the business of the promoting company to approach the big manufacturers connected with the particular trade, to induce them to take space and make a good show. It is from the rentals thus secured that the promoters pay the expenses of the exhibition and make their profits. If the trade patronises it well, spaces let at remunerative rates, and often a handsome profit results; but if the trade fights shy, rent-prices have to be cut, a heavy loss is made, and sometimes the promoting company goes bankrupt. There are, however, in the country, several companies of the kind indicated who have for years past been extremely successful in organising and conducting trade exhibitions; and when their names appear as the directors of an exhibition the trade as a whole shows great confidence, and success is pretty well assured to all concerned.

Obtaining Exhibitors. The method by which exhibitors are secured is as follows. The promoters write round to all the large manufacturers and wholesalers, enclosing them particulars of the proposed exhibition, the hall it is to be held in, the date, the attractions, such as military bands, etc., together with a plan showing the blocks or spaces available, with their prices and dimensions. With the communication goes a form of application which, when filled up, would read something like this: "To Messrs. Brown & Jones, 50b, the Grove, Liverpool. Gentlemen,—I hereby request you to allot me space as set forth below for the exhibition of [here the proposed exhibits must be fully described]. The space is marked 14, and is in the block A on the plan, and the measurement is 16 ft. frontage by 10 ft. side space; total, 160 square ft. For this I agree to pay 2s. 6d. per square foot; total, £20. Deposit £5 is sent herewith, being 25 per cent. of the total amount of rental. This application is subject to the General Regulations and Conditions set forth herein, which I agree to observe."

Conditions for Exhibitors. The regulations and conditions are always set out in great detail, and it is important that an exhibitor should read them most carefully and understand them fully. Summarised, they may be set forth thus: Any variations of the conditions, unless in writing and agreed to and signed by an authorised agent of the exhibition company, shall not be binding upon them. The plan of the exhibition is to be taken in conjunction with the application form, and this is to have the space let marked on it. All contracts for space, etc., are subject to the requirements and conditions of the superior landlords, local and administrative bodies, and guarantee and insurance companies, and all or any having authority through ownership, law, or contract. This is important, because sometimes the catering arrangements of a hall are permanently in the hands of a firm of contractors, and this may prevent a food or drink firm demonstrating and selling its goods.

The exhibition has to be opened on the date fixed by the directors, and it has to remain open on

the days and during the hours advertised. There is, usually, however, a special condition qualifying this by adding that the dates will be kept "unless unforeseen circumstances arise." This clause proved extremely useful to several promoters of exhibitions in 1914, when the great war broke out and their halls were commandeered by the military authorities. Admittance is by ticket, and only tickets issued by the promoting directors are accepted. If by fire, storm, or tempest, riot, etc., or any other cause, the hall or building be destroyed or damaged so as not to be available for the holding of the exhibition, or if for any other unforeseen circumstance the promoters cannot get possession of the hall, then they are not responsible to the exhibitors for loss, delay, expense, or damage, except for the return of the deposit money paid on application for space.

Space must not be sub-let, divided, or held in joint use without the consent of the directors; and if a space is not occupied one clear day before the opening of the exhibition in a satisfactory manner, and in accordance with the purpose for which it was let, then it is forfeit, and the directors may re-let it. This, of course, is necessary, so that the exhibition when it opens may be ready and complete. Stands have to be erected, filled, and removed at the expense of the exhibitors during a specified time decided by the directors, and they must not be removed before the exhibition has closed. All designs for stands are subject to the approval of the directors. This is a very necessary condition, as exhibitors might be putting up small and insignificant stands on large spaces, and the whole exhibition would suffer on account of a mean appearance. Any encroachment on gangways and passages is regarded as a breach of agreement, and this applies to overhead signs, flags, etc., as well as to goods standing on the floor or platform. The directors, however, are always ready to give permission for signs and flags that will not cause any obstruction to other stands or in any other way be an annoyance to exhibitors or visitors.

The directors usually appoint advertising agents, photographers, insurance brokers, stand fitters, and firms to supply power, lighting, heating, and water, and no persons other than those thus appointed are allowed to canvass exhibitors or do work in connection with the exhibition unless, of course, they obtain permission of the directors. This restriction does not, however, apply to exhibitors who employ members of their own staff to do such work as stand-fitting, and so on, but those workers are bound by the conditions imposed upon official contractors.

Delivery of Exhibits. All goods for the exhibition usually have to be delivered at the hall not later than the morning of the day preceding that of the opening. The exhibits must be properly arranged and displayed in time for the opening, and must remain displayed throughout. Perishable goods may, of course, be removed and renewed. The directors take no responsibility for damage or loss through fire, water, tempest, exposure, damp, theft, or any other cause, and exhibitors should always insure in order to cover these risks.

Fitting Up the Stands. Every precaution must be taken in fixing up the stands not to damage the fabric of the hall in any way, and if such damage is done the exhibitor has to indemnify the directors in case of a claim on the part of the owners of the hall. Nothing may be attached to the floor, walls, or fixtures by nails or screws without specific authority having been previously obtained. Of course, no dangerous or explosive article may be brought into the hall by an exhibitor without the previous consent of the directors given in writing, and the quantities of any necessary chemicals or oils must be given.

All the cases and packing in which the goods of an exhibitor have been carried to the hall, after being emptied, must be stored out of sight, either somewhere on the space rented or in some other place, such as a cellar, provided by the directors. Tickets, which are non-transferable, are supplied free of cost to admit exhibitors and their workers.

What Exhibitors may and may Not Do. Exhibitors are usually allowed to distribute literature from their stand, and to sell samples and packages, but they must confine their efforts to their own stand, and must do the distribution in such a way as to cause no annoyance to other exhibitors or to the exhibition as a whole, and they must do nothing that will cause the gangways to be blocked inconveniently. This condition, however, is not always an easy one to fulfil when the exhibit is a really attractive one or when an interesting demonstration is going on. No advertising sign may be fixed by an exhibitor in any part of the hall except in his own space without first obtaining permission of the directors; and no musical instrument may be played in the exhibition without such permission. Even when it has been given, as for a gramophone, if it prove an annoyance to others the authorities may request that it be stopped. Care must be taken, too, that in addressing visitors during a demonstration, or in endeavouring to sell samples, there shall be no undue shouting or noise.

Paying for Space. The usual method of paying for the space rented at an exhibition is to send 25 per cent. of the amount with the filled-up application form, and the balance on the day the exhibition opens. If the balance is unpaid when the exhibition opens the directors usually reserve the right to take possession of the space, retain all the goods that may be there, distrain upon them, and sell them in order to pay themselves the money due, together with expenses incurred in doing all this.

These multifarious conditions may seem somewhat irksome when read, but in practice they work out quite well; and it will be obvious to the least thoughtful of persons that, with such a heterogeneous collection of exhibitors and their employees as is found at an exhibition of this kind, the conditions have to be very definitely laid down so that all may distinctly understand their rights, and not overstep them.

Making the Best of a Trade Exhibition. If the best is to be got out of a trade exhibition, the local traveller or representative of the firm exhibiting should be a good deal in attendance in order to meet his friends and take orders. Wherever possible, demonstrations and workings should be given, as a mere dead exhibit has little to sustain the interest. Machinery, vacuum cleaners, and such like apparatus should always be shown working; food products should be made up in full view of the visitors, who should be invited to taste samples; gas and electric light apparatus should be kept burning; and so on. In this way a double result will be achieved—the trader will be attracted, and the members of the general public who happen to visit the exhibition will be interested.

The dressing of the stand is very much like the dressing of a shop window. An experienced dresser is needed if it is to look its best. Framed diplomas and, where foods are concerned, certificates of purity such as those issued by the Incorporated Institute of Hygiene should be prominently displayed. If the exhibitor's works are distinctive, impressive, well situated, or have anything that is peculiarly attractive, large-sized artistic photographs, well framed, should also be exhibited. Such photographs form an excellent screen for a blind side or back of a stall that happens to be exposed. Where the firm holds a Royal appointment, then the Royal Arms, either in metal or embossed on plate-glass, should be prominently exhibited.

Attendants at an Exhibition. A word must be said about the attendants at a trade exhibition. Where women are employed, as in demonstrations, they must be attractive without being flashy, and should be well dressed, though not showily. If the exhibit is one of foodstuffs, the girls, if dressed in light frocks, neat aprons, and stylish, starched white caps, add greatly to he attractiveness of the stall.

The literature for distribution at the stall must depend for its character upon the nature of the exhibit. In the case of a food firm, pamphlets describing the purity of the ingredients used and the cleanliness of the factory where they are prepared should be prominent, and also well-illustrated recipe booklets, giving many ways in which the particular food product in question can be used. If the article is a household one, like a vacuum cleaner, then the literature should contain a full description of its advantages and clear details as to how it should be used. For exhibition purposes cheap leaflets are of little use. The crowd is a more or less selected one, and while cheap printed matter is certain to be thrown away, thereby littering the hall, the better type of pamphlet will probably be carried home.

Sometimes the addresses of visitors may be secured, under the plea that a booklet is to be posted on, and a list of such addresses is always useful for future circularisation through the post.

General Exhibitions. The conditions and regulations for a general exhibition intended primarily for the public and not for the trade are very much the same as those already described. For sampling and demonstrating the same care has to be taken not to infringe the rights of the refreshment contractors of the hall, and, of course, the rules as to what may be an annoyance to neighbouring exhibitors or to the exhibition generally are even more stringent than in the case of the trade exhibition. At some of the smaller public exhibitions arrangements are sometimes come to by which only one firm of a particular trade or class is allowed to show. In such a case the value of the publicity to those firms which exhibit is greatly enhanced, as the absence of rivals concentrates the whole of the attention on the particular goods shown by the single firms admitted. A monopoly of advertising in such circumstances is all for the good. Incidentally, it may be mentioned here that monopoly of publicity is not always to be desired. Many a demand of the public would never have been created at all if the work of creating it by publicity had been left to any one firm. It is the multiplicity and variety of advertising, together with the competition of rival firms, that makes a lasting public demand, and turns what may have been considered a luxury into an absolute necessity. The huge sales of beef extract made by a number of big manufacturers, a demand that has only existed during the past quarter of a century, is a striking instance in point.

Rival Attractions. At a big public exhibition, largely supported by Government authority, the exhibits are generally so good that they render it necessary for the manufacturer of or trader in mere household commodities to make a very large and attractive show if he is to get the attention of visitors at all. A mere dead exhibit, unless it is very prominent indeed, is not likely to be seen by many; and it is important to remember that in a general way, unless a good deal of money is going to be spent in arranging an exhibit at a big public exhibition, it is not worth while to go in at all. A small stand that might be excellent for a trade exhibition or a local show is worse than useless for a large national exhibition like those held from time to time in London or other large cities. By its very insignificance it is apt to give a wrong impression of the firm, the public judging of the relative importance of rival firms very largely by the size and attractiveness of their exhibits.

Distribution of Literature. At these large exhibitions the number of visitors runs into millions, and it is obviously impossible to give to all anything like an adequate supply of the best literature. This renders it necessary that the attendants should be men or women of discretion. Discrimination must be made; and while there may be folders and leaflets for general distribution, the more expensive booklets should either be kept out of sight or in such a position that they have to be asked for. An enormous proportion of the people who visit a big exhibition are on the look-out for something for nothing, but, as a rule, these are the people who are not worth attracting, anyway for a high-class commodity. Anything like dainty booklets with artistic covers should always be enclosed in envelopes, so that the recipients may be able to get them home in a clean condition. A little fingering, in hot weather particularly, will soon spoil the appearance of a dainty booklet, and as a result its appeal is largely lost.

Carrier Bags. Where small goods, foodstuffs, etc., are being sold, carrier bags should be provided, so that customers may carry their purchases away conveniently. These bags are usually made of stout brown paper, with eyelet-holes and string handles, and on the sides are printed the name of the firm, and perhaps a line of advertising or the name of some special proprietary article. The advertisement must not be too blatant, or women will not care to carry the bags, but if the printing is neatly done in a high-class type, then the bags will not only serve the useful purpose for which the customer welcomes them, but they become valuable advertising media too. Such bags, if well and strongly made, are not thrown away when the goods reach home; they are carefully preserved for future use, and often hang in the kitchen as receptacles for string, etc., where the printed name of the firm is a more or less permanent advertisement. A warning must here be given in connection with carrier bags: see that the eyelet-holes are well protected with discs, so that the string does not easily tear away from the bag. It is very irritating to a woman to find, after carrying her bag for half an hour or so, that the string handle comes off, rendering the bag practically useless for its purpose.

Lighting. The artificial lighting of a stand must always be good. Nothing is worse than an inadequate supply of lamps. It is not so much in the quantity of the lamps used as in their illuminating power, and electric lights are generally more suitable than gas. First of all, they throw out less heat, and the heat in an exhibition hall on a warm summer evening, when people are crowding in, is apt to be very oppressive. Anything, therefore, that will lessen this is good, not only for the exhibition as a whole, but for the individual exhibitors also. Very often it is necessary to have some artificial light during the day, as, where a hall has a large expanse of glass roof, blinds are usually hung across to protect the hall from a glaring sun; and, on a dull day, unless these hangings can be removed, the amount of daylight will be quite inadequate. Of course, the stands will always look better when they are well lighted at night by gas or electricity, just as the stage of a theatre is at its best when seen by artificial light, the only conceivable way of seeing it to advantage.

Position of a Stand. Great care must be taken in the selection of a position. It is unwise to get too near the band, for instance, as when this is playing, and the people crowd round, that is naturally the overwhelming attraction, and the backs of the visitors will be turned to the stand, and their faces to the band. The sound of the music, too, will drown the voice of any attendant who may be trying to speak to visitors, or describing a process or article during a demonstration. A position too near the entrance is to be avoided, as when people come into an exhibition at first, they walk on some distance before their minds have become attuned to the idea. What they see first makes very little impression upon them, as they are thinking about getting farther on, so as to obtain a general impression of the exhibition as a whole. For household commodities, at any rate where the desire is to attract the general public, a position near the entrance to lavatories should be avoided.

Then, again, a stand should never be next to another stand belonging to an exhibitor in the same line of business, if it can be avoided. Whenever possible, an exhibitor should see the hall before deciding upon the space he will take, for in addition to the general principles of selection given above, there are various local considerations confined to particular halls—draughts, windows, doors, posts supporting the roof, etc. The latter are often a great nuisance, and may seriously impede access to a stand, or spoil the general effects of its contour. Another consideration that must be taken into account where food or washing demonstrations are to be given is nearness to the water supply, unless, of course, water is to be laid on to the stand. This latter is a considerable expense, and is not always necessary, unless a great deal of water is required continuously.

Importance of Good Attendants. However good a stand may be, and however well the exhibits are displayed, the effect is largely lost unless the attendant is capable. This applies to the general exhibition as well as to a trade exhibition. Of course, in the case of dead exhibits, there is no attendant. The display is merely that of the shop window without the shop, but such methods of utilising exhibitions are not now in much favour. It is felt by most manufacturers that, in addition to showing their goods, they must have a competent representative to emphasise their points, and, incidentally, to take orders. Attendants, whether male or female, should always be well dressed.

Much, of course, depends upon the nature of the exhibit. For dry-goods, a man should wear a morning-coat and spotless linen; for fancy goods, women attendants should be dressed much like the best class of drapers' assistants; for demonstrations of cookery, men should be attired in white, with white caps, like hotel chefs, and women should wear large fancy white aprons and caps. For all domestic exhibits, where the idea is to attract the housewife, it is important that women attendants should give no impression of flashiness. This is a consideration too often overlooked by exhibitors, but it will be understood that any such impression given to lady visitors will naturally prejudice them against the stand and exhibit. The women attendants must, however, be attractive, good-looking if possible, very neat and tidy, and with a pleasant, appealing manner that holds the listener.

Travelling Exhibitions. Another type of exhibition, one which is perhaps of more value to the manufacturer of household commodities and articles than any other, is that of the travelling syndicate exhibition. In this case a number of big manufacturers get together and form a syndicate to run a permanent exhibition that shall travel from town to town all the year round. A manager and staff are appointed, and only one manufacturer of each particular trade is allowed to be a member of the syndicate. In this way each exhibitor has an absolute monopoly, and excellent work in the way of publicity is done. There are several such syndicates, each having from fourteen to eighteen members. It is found in practice that with fewer than twelve or fourteen the exhibition is more expensive to run than it need be, its overhead charges being unduly heavy per exhibitor, while with more than eighteen it is difficult to be sure of getting halls in the various towns visited that are large enough to accommodate all the exhibitors.

The method of working is as follows. Each exhibitor pays a regular subscription—about eight pounds per town visited. For this he has a certain regulation space allotted to him, and the services of the staff in managing the exhibition, erecting his stand, etc. Any special requirements, such as the laying on of water, etc., he pays himself. He also pays the wages of the attendants at his own stand. The subscription, however, includes printing, programmes, advertising, the services of a band, and other attractions. Where the syndicate is run well, there is usually a profit after each exhibition, which is divided among the syndicate members; and as good sales are made at the individual stands, an exhibitor may almost recoup himself for the outlay. As the plan followed gets the goods right into the hands of the public in the very best circumstances, it may be said that the syndicate exhibition is not only one of the cheapest, but also one of the very best forms, of advertising known. This applies, however, only to household commodities, as the type of exhibition is distinctly and exclusively one for the housewife. Cookery and laundry lectures are given, and visitors instructed in new ways, and the best ways, of using the goods of the various firms exhibiting at the stands.

Local Exhibitions. Many of these are held, and it is safe to say that quite 50 per cent. are of no use at all to the advertiser. If the entertainment element predominates, the manufacturer will do well to keep out, but on the other hand there are many good local exhibitions where excellent publicity can be had for proprietary household commodities at a reasonable outlay. In such cases, and indeed in most cases of exhibition publicity, it is well to

support the show by using the local newspapers. The spaces taken need not be large, but they should be in good positions, and the feature of the announcement must always be that the article may be seen or tasted at the exhibition now being held in a certain hall. The advertisement should appear in the papers on the opening day, and once or twice afterwards.

Foreign Exhibitions. Foreign exhibition propositions must be handled with great care. Of course, there are some of these which are invaluable to manufacturing firms desiring to secure a large share of the export business, but on the other hand many foreign exhibitions are not worth going into. The advertiser must be guided by personal considerations. If he wishes to increase his business in France, an exhibition in America is of no use; and it is practically a waste of time and money to go into a big Continental or American exposition unless the effort is to be supported and followed up by other methods of publicity and salesmanship. Attendants at such exhibitions should always speak the language of the country perfectly, and it is essential that they should know the trade customs of the country.

It will usually be found more economical when exhibiting abroad to get a light stand fitted up locally, rather than to send a heavy stand from home. Freights, etc., are extremely high, and the risks of getting the stand damaged are great.

Important Points to Remember. An important point to remember in connection with all exhibition advertising is that the first offer of space must not be accepted, however plausibly it may be backed up by statements that sites are letting fast, and that in a day or so no space will be available. It is practically always safe to wait a little, and usually a second or third offer will be accompanied by a note that for this occasion only a cheaper rental will be taken. On the other hand, an exhibitor should not hold back too long if he really wishes to go in, or he may find that the space he desires is let over his head.

Another very important point to be borne in mind in connection with all exhibitions is that stands and goods must be despatched at the right time. On no account must they be late in arriving at the hall; and if there are any exceptional circumstances, as in war time, when delays may be anticipated on the railways, then an extra day or so should be allowed. But we should not go to the other extreme, and send off our goods too early, as they may not be accepted at the hall, which will possibly be in other hands at the time, and a more or less heavy demurrage will be the result.

Permanent Exhibitions. There are one or two permanent exhibitions from which good publicity can be obtained. One of these is the exhibition of the Incorporated Institute of Hygiene, which has on its governing body more than fifty of the leading scientists of the country. This institute grants a certificate of merit for first-class commodities, and space can be rented quite reasonably in its museum by those firms who succeed in passing its test. The exhibits represent not only foods and drinks, but all kinds of hygienic appliances—baths, hot water apparatus, etc. The advantage of getting a show in this exhibition is that, while not a large number of the general public go to see the exhibits, visits are organised of bodies of influential persons, such as doctors, schoolmasters, nurses, and so on, people whose opinion counts, and who have much to do in directing the public. The institute also makes reports upon commodities, and these reports are well worth quoting in advertising literature, coming as they do from such an authoritative source.

Shop Demonstrations. Another form of publicity allied to exhibitions is that of giving demonstrations in shops and stores. This has proved extremely successful with household articles, and is in great favour with large manufacturing firms. Part of the counter may be used, or a small stand, or even a table may be set in the body of the shop. As good a display as possible of the demonstrating firm's goods is made in the space available, and a female attendant gives the demonstration, either at stated periods, say, every half-hour, or more or less continuously throughout the day. The demonstration may last a week, a fortnight, or even three weeks, and the shopkeeper supports it with a full window display, a distribution of invitations to his customers and to the better class of inhabitants round about, while bills on the shop window announce to the general public that the demonstration is being held inside, and that they are invited to walk in. If the shop is a very large one, the most prominent position available should be selected, and a space fairly near the entrance is good, because all who come into the shop then have to pass the place. In a large store, the demonstration will take place near the entrance to the particular department in which the article in question is sold.

Cost of Shop Demonstrations. Nothing definite can be said as to the cost of shop demonstrations. They vary according to the establishments in which they are being given. The large stores usually charge pretty stiffly for the use of the space, and in addition there is the cost of the material used, the advertising matter distributed, and the demonstrator's wages. If the demonstration is of a food cooked in various ways, then in addition there will be the cost of an attendant for washing-up purposes.

In smaller establishments, however, the space is usually given for nothing, and the shopkeeper is ready to lend every assistance to make the demonstration a success, for he realises, if he is an enterprising man, that the effort will result in increased business, to the mutual advantage of himself and the manufacturer. In such a case the general plan is to take from the shopkeeper's stock whatever materials may be required for the demonstration, paying him for them, and also for the manufacturer to pay for all advertising matter required—window bills, invitation cards, etc.

Often the shopkeeper can be induced, in return for the demonstration, to give a substantial order, the incentive held out by the manufacturer being that a greatly increased demand on the part of the public will warrant, and, indeed, necessitate, a more extensive stocking of the lines demonstrated. Here, again, the effort is largely lost if it is not followed up by other efforts from time to time. A booklet with a circular letter could be sent to each customer after a month or six weeks; this might be followed by another letter with a sample, and so on, everything, of course, being done in conjunction with the trader in whose shop the demonstration was given.

Window Displays. For all branded proprietary articles, whether foods, drinks, medicines, gas-burners, lawn-mowers, etc., window displays are very effective forms of publicity. They have this advantage: that the spectator who sees and is favourably impressed has an opportunity then and there of going in to buy the article. This is an opportunity he does not get

when reading an advertisement in a newspaper or magazine; and though he may be impressed at the time of reading, and determine to buy the article, yet enthusiasm and ardour are apt to cool off.

The method of obtaining a window display is to offer the shopkeeper some inducement in the way of a special discount or bonus on the goods he buys, or to give him free of charge a certain proportion of the goods required for the display. If a whole window can be obtained, so much the better. It takes a good deal of stuff, of course, to fill a whole window, but a large proportion of the things shown may be dummy packages provided by the manufacturer. When the display is in the window of a well-known shop, it always pays to take space in the local newspaper so as to draw the attention of the public to what is going on, and the cost may be shared by manufacturer and shopkeeper if necessary. The advertising department of the firm whose goods are being shown will have to prepare some attractive window bills, folders for distribution, etc. If a simultaneous series of window displays can be arranged throughout the country, or the district, or in the same town, so much the better. The cumulative effect brought about by the public seeing the goods everywhere will be very great and leave a lasting impression.

Bazaars and Sales of Work. Somewhat analogous to the forms of publicity already referred to above is the supplying of sample packages, free of charge or at a reduced rate, for sale at bazaars and sales of work. Most manufacturers of household commodities do a good deal of this, and it is certainly an excellent way of advertising and of putting one's goods right into the hands of the people. The articles need not be given; they can be charged for at such a rate as will practically cover the actual cost of the goods, though carriage and packing will be an out-of-pocket expense. The prices at which the articles are to be sold should be specified, and they should enable a profit of 100 per cent. on the cost to be realised. Great care must be taken that only sample packages are given for this purpose, or the manufacturer will find that he has set the local retailers against him. In addition to the advantage of having the goods actually taken into the homes of those who buy them, there is the publicity which comes from the display of them on the stall at the bazaar or sale, and very often an announcement is printed in the handbook giving the names of the firms who have assisted. Worked in the way indicated, this is a cheap and very efficient form of publicity.

Sampling Schemes. Another form of advertising which manufacturers have found successful in its results, especially with a new article, is that of distributing samples on a large scale. It is a very expensive form of publicity, but, as the final and permanent results so often prove really good, it is cheap in the long run. It is a method of advertising, however, that wants most exhaustive thinking and working out beforehand, and the cost wants very carefully estimating.

There are various ways of distributing the samples, each having some advantage over other schemes, and before any step is taken the particular scheme to be followed must be definitely decided. First of all, is the distribution to be general or local? The decision almost invariably arrived at is that it shall be confined to a certain locality, for anything like a general distribution of samples throughout the country is too expensive to be attempted at one time, especially as the mere distribution of samples is only a part of the campaign. This must be supported well by other forms of publicity, such as newspaper advertising, announcements on the hoardings, and the distribution of literature.

The next step is to decide how the samples shall be actually placed in the hands of the public. The cheapest way is to get the shopkeepers to do this; and if they can be enthused and made to see that every sample distributed is a silent salesman bringing them future customers, and if, realising this, they will themselves support the effort with recommendation, then the method is excellent. But many shopkeepers—especially the smaller ones, living self-centred lives—are so unappreciative of these efforts on the part of the manufacturer that they are not often ready to give their enthusiastic support.

Another method is to get a list of names and addresses, as up to date as possible, with the ineffectives weeded out by someone on the spot who knows, and then to post the samples addressed to each lady or gentleman, as the case may be, by name. Anything like a general inscription, "To the Occupier" or "To the Lady of the House," is to be strongly deprecated. Such methods belong to the past and are thoroughly worn out. Envelopes thus addressed bear on the face of them the obvious stamp of a wide advertising scheme, whereas the actual name of the person it is desired to reach gives an air of individuality to each package that is worth a great deal in arousing interest. Even if a large proportion are returned because the person named has gone away, it is worth while, in order to reach in so effective a way the remainder. For the same reason as we avoid general addresses, we should never have advertising packages franked in thousands at the post-office. Let every envelope bear an ordinary penny stamp—not a halfpenny one. Posting the samples is very good, but it is very expensive indeed if done on anything like a large scale. The prime advantage is that the sample is certain to get into the hands of the person for whom it is intended, as servants will not open a letter properly addressed to their employer and received through the post.

House to House Distribution. The most usual method of distributing samples on a large scale is by a house to house visitation. The first thing, after deciding the district or town to be visited, is to make a selection of streets to be worked. This should be done by someone who knows the district well, and can indicate the most suitable thoroughfares. In selecting these the poorer working quarters should be avoided, unless the sample to be given away is of some household necessity the selling point of which is cheapness. At the other extreme, it is seldom profitable to distribute samples at the doors of large houses where more than one servant is kept, for in such cases the packet is not likely to reach the lady of the house at all; it will certainly not get farther than the servants' hall. For this type of large house the postal system is best.

Having decided upon the streets, these should be marked in some way on a large-size, fold-up map. One way of doing this is to shade with a blue pencil the districts to be worked. The order in which the streets are tackled is best left to the person who has charge of the distribution. For this work it is not always easy to get a suitable man. The kind of person required is one with a good deal of tact, and considerable experience in managing people. He will have to keep his distributors in good humour, will have to see that they work energetically, will have to see that no packages go

astray, will have to check off the streets as they are worked, and may have to placate angry and unenterprising householders who object to receive something for nothing.

Since the advent of notices on gates and doorways, "No circulars, no hawkers," etc., the distribution of samples requires more tact than ever; and unless the person in charge is one with a good knowledge of human nature, the effort is liable to do more harm than good.

The Barrow and Distributors. The usual plan is to have one or more gangs, each of four men, with a youth to push the barrow in which the samples are carried. Where several gangs are at work in a district, the barrows are replenished either at a central depot or by means of a horse and cart, the latter containing a full day's supply for all the gangs at work. The carts and barrows should be attractively decorated, with the name and business of the firm conspicuously displayed.

The men who are actually doing the distribution under the overseer must be carefully chosen. In normal times there is no lack of men who will apply for such work when it is advertised, but a large proportion will be found to be ne'er-do-wells. Good references from more than one previous employer should always be insisted upon. The reputation of a firm is almost certain to suffer if its goods are given out from house to house by men of doubtful appearance or character, especially if they should be the worse for drink. As far as possible. abstainers should be selected for this work.

Uniforms of some kind should be provided for them, if only a cap with a coloured riband round it bearing the name of the firm. Also, it will be necessary to provide for each man a sou'-wester hat and waterproof cape and overalls. The wages paid will be about 25s. per week, the day being from nine to six, and from nine to twelve on Saturday. It is unwise to begin a distribution before nine in the morning, as householders do not want to be disturbed during the breakfast-time.

Method of Distribution. The usual way of working is to let two men go down one side of a street, and two men down the other. Both pairs will thus get to the end of the street at about the same time, and the barrow can move down slowly, keeping pace with the distributors. The men carry either satchels, slung round their shoulders, or handbags, and in these they take a certain quantity of samples, varying according to the size and weight of the packages. When his bag is empty a man goes to the barrow and loads up the satchel again, the barrow man keeping a note of the number served out to each individual on each occasion. In all cases the quantity should be a certain specified number of packages—say, twenty-five—and if all the men are honest there will be no difficulty in keeping a proper check. The men on each side take alternate houses, and thus keep together as they go down the thoroughfare.

If several groups are working in a district, the overseer will have to be a very energetic man if he is to keep his distributors up to the mark. His plan will be, of course, to dodge here, there, and everywhere, so that the distributors never know when and from what direction he will appear.

The men must be engaged on a weekly basis, unless they are local men, and if they are taken from town to town their fares must be paid. An hour should be allowed for dinner each day. Every evening the overseer must send to his firm a sheet showing any expenses incurred, a list of streets done, with remarks about any particular houses that need comment, and a general report as to the weather, the men, the reception of the samples, etc.

The Samples and Literature. In making up the packages, they should be neat and attractive. With the samples will be enclosed some literature, but not too much. One really attractive and interesting-looking booklet, telling the whole story about the firm and its products, is better than half a dozen of varied sizes, qualities, and subjects. There is always the danger—in many cases amounting to a certainty—that a great wad of printed matter will be thrown away bodily without being looked at. In any case, the sample should have enclosed with it a form letter, brief and to the point, telling the recipient what the article is, and asking him or her to try it.

Form Letters. These form letters must be very carefully prepared. They should be typewritten in appearance, and not set up from printers' type, however good it may be. Duplicating appliances like the Gammeter Multigraph, already described in the Business section, have been perfected, and are able to produce circular letters almost as fast as a printing-press. The great advantage of such an apparatus is that the letter is actually the same as a typewritten document, for the type does not print direct upon the paper, but through an inked ribbon in the same way as the typewriter; and as the type of any of the standard typewriters may be used with the instrument, names and addresses and dates may, whenever desired, be filled in to match the letters. Form letters should always be short, never running to more than one page of quarto notepaper.

Working the Trade. Of course, if a sampling scheme such as that described above is to be carried out in a district, the trade there must be thoroughly worked beforehand by the regular salesman, or a special man put on for the purpose. The shops must be stocked up, so that when the demand is created, and people begin to ask for the goods, they can obtain them without delay. If they fail the first time, they may not ask again. If a large number of shops are thus stocked up, it is sometimes a good idea to send out with the samples a list of the shops in the neighbourhood where the goods may be obtained. By letting the shopkeepers know this beforehand, it is often possible to get those to stock up who would otherwise not help in the scheme. They are anxious not to lose the publicity that results from their names being on the printed list. This important detail of working the trade in connection with a sampling scheme is a proof of how essential it is that the sales and advertising departments should work together.

Another Method of Distribution. Another method of distribution organised by agencies that lay themselves out specially for this work is for lady distributors to go from house to house selling, not giving, the goods. Simultaneously they work the trade, and all the goods sold to the householders are bought from the stock of the shopkeepers. This is done so that the local traders may not be upset by the scheme, but any plan of this kind needs great care in working out, as the shopkeepers are proverbially suspicious of all schemes in which the manufacturers go direct to the consumer. In any case, it would be unwise for any manufacturer to attempt such a scheme direct with a staff of his own. It is best left to the agencies who specialise in it, who know the ropes, and who have a thoroughly trained and experienced staff of competent women workers.

Organised Visits to Factories. Somewhat analogous to exhibitions and demonstrations are the organised visits to their factories which many manufacturers now encourage. It is always a sure way of interesting the shopkeeper in the goods he sells if he can see them made; and in the case of food products, if the conditions of manufacture are all that can be desired from the hygienic point of view, then too many people cannot pass through the factory. For trade visits, the best plan is to organise an outing for the trade association of some particular town, getting the permission of the officials to allow other trades to join who do not happen to be members of the association, although they are good customers of the manufacturer. Such customers, when outside the trade organisation, must not be ignored.

In some cases, where an association has asked to be allowed to visit the works, the members would pay their own fares to the nearest station, while if they came by invitation of the manufacturer, he making the first approaches, fares would probably be paid by him. The exact plan to be followed must be decided according to local conditions. If the works are in or near a town which has objects and buildings of great historic interest, then a drive round the town, with a call at the more important show-places, could begin the day's festivities. Luncheon may be served at an hotel or in the works, according to facilities, and at this there may be speeches and toasts or not, according to taste. But in any case the chairman—who will be the managing director, sales manager, advertising manager, or some other prominent official—will give a welcome to the visitors and outline the afternoon's proceedings.

The trip through the factory will be made in parties of a dozen or so, each party being conducted by a guide; and the visitors must be well schooled beforehand not to speak to the employees, not to wander about away from their guide, and not to interfere with the work that is going on in the various departments. After the journey through the works, tea should be served, and the proceedings may be wound up with an impromptu concert, unless, as is done by some firms, a dinner is to be given in the evening. This would, of course, have to be at an hotel, unless there were special facilities for catering at the works. Whatever amenities there may be, the last impression the visitors receive, the one that they will take away with them, should be of the factory and firm, and the products it turns out. There should always be a sample-room, well stocked, into which the trade visitors can go and see the latest lines, and here the sales manager and his assistants should be ready with their order-books, although solicitation for orders on such an occasion would be out of place. Solicitation, however, will not be necessary, for the experience of firms who go in for this form of advertising is that if the visitors have enjoyed themselves, and been impressed with what they have seen, they will show their appreciation by giving orders.

The General Public. Visits of this kind, however, should not be confined to the trade. The general public should be invited, and the more the merrier. Some firms issue a standing invitation to consumers of their goods, vouchers being enclosed with their packages. In these cases, if the factory is easily accessible in a large town, and the number of people who will respond may be anticipated to become large, it is best to set apart a certain day or certain days per week, so that the visits may be concentrated. In this way, time will not be wasted.

But not only should members of the general public be thus invited promiscuously. Visits of representative bodies should be organised, particularly in the case of firms producing foodstuffs. There is an enormous number of associations available—learned societies, medical and municipal bodies, religious and temperance organisations, suffrage societies, etc.; and women visitors are even more valuable than men, for if they go away enthusiastic and impressed they talk more than the men. Each lady becomes a walking and talking advertisement.

Of course, in taking visitors round, a certain recognised route can be followed. It is not necessary to let everyone see everything; and in the case of one large firm that invited a body of visiting burgomasters to see their works, so that these foreign business men should not see too much a doorway was made specially in a particular wall, in order that it should not be necessary to take them through certain departments of the factory.

Souvenirs for Visitors. Of course, it will be necessary to have some suitable souvenir prepared to hand the visitors as they leave, and this should be of such a character that it will be kept, and act as a constant reminder to the visitors, long after the visit is over. The particular form of the souvenir must be decided by each firm for itself, but in any case it should be thoroughly well illustrated; and if the pictures can be in colour, excellent effects can be obtained in two colours.

The reading matter should not be too long, but it should be descriptive of the factory and its products, and should tell the whole story in a bright and connected manner. The booklet could be packed in an envelope with some other advertising literature, but the main booklet should be distinctly a souvenir, and should be called by that name.

Following up a Visit. All visitors should be asked to sign their names and addresses in a visitors' book, and this then becomes an excellent register of people interested in the firm and its productions. Should any new line be brought out, here is a carefully selected list ready to hand for advertising or sampling purposes. But, apart from new lines, the firm should keep in touch with these people, and any new booklet could be posted to them, together with a form letter reminding them of their pleasant visit. So far as trade visits are concerned, the statistical department will keep a record of the visitors, and from time to time their record of business will be looked up and compared with the corresponding period prior to the visit. It will then be seen to what extent business has been increased and helped by this form of publicity.

School Advertising. A form of advertising regarded as very valuable by many firms is that in which picture diagrams, booklets, and museums of products are sent to schools. With regard to the latter, the museum is, of course, costly to prepare. There is the case, consisting of a mahogany and glass cabinet for standing, or hanging on a wall. And then there are the various products to be placed inside. But if the teachers are going to give object-lessons on the products to succeeding generations of boys and girls, who will be the mothers and fathers of the future, then for household commodities this is certainly a method of publicity that should have far-reaching effects. The objects in the museum should, as far as possible, show the successive stages through which the product goes before it becomes the finished article known to commerce, There should, if possible, be the raw material.

and any stages which cannot be shown in the product itself can be shown by pictures.

The museum cases should, of course, have the name of the firm conspicuously displayed in gilt, and it should be understood that it is to stand in the school hall. Some of the contents will probably need periodical renewing, and some arrangement should be made with the schoolmaster to let the firm know when this is necessary.

Large coloured showcards illustrating methods of manufacture are also welcome in elementary schools, and if they are displayed on the walls of the hall they form an excellent advertisement. Another form of advertising in schools is to supply dummies and samples for use in model shops. This is the way in which arithmetic is now taught in many schools; and it is obvious that the name of a firm whose jams, cocoa, mustard, or soap is being constantly handled, talked, and written about will remain in the minds of the children, and probably recur later on, when, having grown up, they engage seriously in housekeeping on their own account.

At Christmas-time there is always a demand for toy-books, coloured picture-postcards, novelties, and similar advertising matter for distribution among children, and hundreds of thousands of pounds are spent every year by the large manufacturers in preparing material for use in this way. Such advertising is not merely laying up treasure for the future, but it has its present advantages, for much of it is talked about in the home, and so the present buyers are influenced and have the names of manufacturers brought frequently before them by their children.

The media of advertising are, of course, legion, and no firm, however large its annual appropriation, can afford to use all or anything like all the fields that are open to it. A selection must be made; and the particular nature of the selection depends upon the character of the business to be advertised and the class of people it is desired to reach.

New realms for the advertiser are constantly opening out; and as an example of how opportunity may be seized and current happenings be harnessed for the purposes of publicity, we may refer to the shades used to darken the lights in shops and omnibuses during the time that aircraft raids were expected over London and other large cities. Advertisers saw their chance, and quickly seized it, and thousands of shades came into use bearing upon them the names of somebody's soap or such-and-such a food. Sometimes the advertisement was printed on the paper, and at other times the letters were cut out and filled in with a different coloured paper from that used for the shade itself, thereby making a very effective notice when the lamps were alight. The space available will allow of nothing like an extended description of all the media open to the advertiser, but brief references may be made to the more important not yet touched on.

Railway Advertising. One very important branch is railway advertising, and this is so varied that in itself it would provide sufficient for a lengthy volume. The oldest and most obvious form of railway advertising is that at railway stations, and very large revenues are made annually by the railway companies from this source. It is certainly effective, despite the fact that in the rush and hurry of catching trains people might be expected to have little time or inclination to attend to such matters. On the other hand, it must be remembered that there is a good deal of waiting about at stations, including the great terminuses, and people are glad of something to look at. On such occasions there is little inclination to read books or even papers; and there is no doubt that constantly seeing an announcement about some article of wear, some magazine, some household commodity, or a tobacco or drink, does leave an impression on the mind. The effectiveness of advertising in this way at railway stations has been proved again and again, and some articles which are now household words have had their reputations and extensive sales built up almost exclusively by publicity at railway stations.

Enamel Plates. The general method in vogue is to do the advertising by means of enamelled iron plates. These can be exceedingly attractive; very bright colours are attainable, and they have the great merit not only of resisting the weather but of being easily cleaned, and a good rainstorm improves them, for it acts as a bath. This station advertising is in the hands of responsible agents, who charge so much per square foot per annum by way of rental, and for good-sized orders they will usually prepare the plates free of charge. The rental, too, is generally on a sliding scale, according to the size of the order. The advertiser is allowed to select his stations, and, as far as they are available, his positions, being taken round for this purpose by the agent.

The first thing to decide upon is the amount to be spent at the stations, then to arrive at the number of square feet this will purchase, and then to fix the exact size the plates are to be. The temptation is, of course, to reduce the size of the plates and increase the number of stations, so as to get as wide a publicity as possible. But very great caution must be exercised in the matter; for in the multitude of announcements that now crowd our stations, unless one puts up a plate of a fair size, it will be buried or overshadowed.

Restricting Wording and Colouring. Another great temptation in railway-station advertising is to want to say too much. The name of the product, the phrase of two or three words, is all that the public can safely be expected to take in in the peculiar circumstances of the case, and by overcrowding the announcement practically the whole of the advertising may be lost. In some cases it may be wise to give a reproduction of the article or package advertised, but this is not often necessary, and is not generally done, as a glance at any great terminus will show. When, however, there is something peculiar about the package, as in the case of the bottle in which a certain tooth preparation has long been sold, it is excellent publicity to show this.

The particular colours to be used need a good deal of thought, and here, again, the temptation is often to overdo the business, to use a variety of colours where two or three will give a more striking and effective display. It is wise to look and see what are the prevailing colours being used, and as far as possible to get something different, but the striving after variety and individuality must not be strained to the extent of turning out something that, while different, is also ineffective. The best colour for a background—that is, for the body of a plate—is red or yellow, the former not crimson but a bright scarlet or vermilion, and the latter a rich canary or chrome. On the yellow, black letters show up best, and on the scarlet black or white look well. Black should never be used for a background, as it is too sombre, and this applies in a less degree to other very dark shades, such as a deep bronze-blue, and the like.

Inspecting Railway Announcements. When the plates have been prepared and fixed in the positions selected, a visit should be paid to all the stations, to see that they are actually up in the places arranged; and while the agents will undertake to see that they are kept in a clean and fit condition, it is not wise to leave the matter entirely to them. Periodical visits should be paid to the various stations, just for the satisfaction of knowing that all is right. Any firm advertising in this way should make good use of its statistical department, watching the amount of business done at the various places where the plates are showing; and it will be seen after a few months whether the publicity is bringing results.

Announcements in Booking-halls. A new method of advertising at the great terminuses and the larger stations has quite recently come into operation. This is by means of advertisements prepared in inlaid wood and arranged in panels round about the pigeon-holes where tickets are served out. They are rather dull in appearance, but as most booking-halls are dismal places, and there are few counter-attractions, they may do some good. But it is a great question whether publicity of this kind in such a place is of such value as to warrant the expenditure involved. Booking-halls are not, like platforms and the great central halls of stations, places where people hang about, and are therefore glad of something to read. Travellers usually get their tickets with as much expedition as possible; and if they have to wait in a queue to get to the window, they are too intent upon the business in hand to concern themselves very much with advertisements that appear an inch or two from their faces.

Advertisements in Railway Carriages. Some of the railway companies take advertisements for the insides of their carriages. In some cases these appear in panels just under the luggage-racks, so as to face the traveller, and in others they appear as narrow panels on each side of the carriage door. This latter position is, of course, not so good as the first-mentioned. Under the rack and above the heads of passengers sitting on the seat, an advertisement can be seen by all on the opposite seat; and as the companies have for years past educated the public up to looking at these panels, by placing excellent views of beauty-spots in them, there is no doubt that good publicity can be obtained by taking a range of such spaces. The rentals are not dear, and the best trains are, of course, the suburbans and locals, as they carry a constant succession of different passengers.

On the London underground railway and tubes, the announcements appear in various places—above the windows on each side of the carriage, on the woodwork between the windows, on some of the seats, at the ends of the carriage, etc. The number of passengers carried in the course of a year is enormous, and the publicity obtained is very valuable. Almost the same remarks that were made in connection with the announcements on enamel plates at stations apply to the announcements inside railway carriages. They must be brief and the lettering as large as possible. The spaces are very limited in size, and if much matter is inserted the type will have to be so small that from 25 to 50 per cent. of the passengers will never be able to read it at all. Some of the companies put certain restrictions on the design and colouring and in a general way the design and colouring do not need to be so striking as in the larger outdoor advertisements.

Railway Ticket Advertising. The latest development in railway advertising is in connection with the underground railways of London, certain of which are taking advertisements for the backs of their tickets. A few years ago such a move would have been thought inconceivable, but there is no doubt that the innovation has come to stay, and that it will before long be extended to other lines too. Of course, there is probably less value in an announcement on a railway ticket than on a ticket for an omnibus or tram, for whereas the passenger may, if he wish, retain the latter, the railway ticket has to be surrendered at the end of the journey. Not only so, but when people travel by train they are usually equipped with reading matter, and are far less in the habit of looking at their tickets than when on the road vehicles.

The companies, however, do their best to make the advertising useful, drawing attention to the tickets by means of announcements posted up at the entrances to the stations, and by other means.

Tramcars. From railways it is not a far thought to tramcars, and here a good deal of publicity of an excellent kind is available. The tramcar may almost be said to combine a good deal of the advantage of the poster on the hoarding with the circulation of the newspaper, for while the outside announcements on the car are, in effect, posters, the tramcar, moving backward and forwards through miles of crowded streets, reaches a far larger circle of the public than any mere stationary poster on a wall or hoarding. It is brought before the notice of people in the streets, and it is equally visible to the thousands of people who live in the houses on either side of the thoroughfares through which it passes daily.

The advertisements on the outsides of tramcars are prepared on enamel plates just like those at railway stations, and they run round the top of the car, but the whole area need not be taken, as the space is divided generally into sides and ends. In many towns, too, narrow enamelled plates are fixed to the drop of each step on the staircase back and front.

Window Transparencies in Cars. The advertising inside the cars is in the form of transparencies on the upper lights of the windows along each side, and are intended for the perusal of passengers, but some advertisers have at least one transparency turned so as to read from the outside. This, of course, is only legible after dark, when the car is lighted inside. It is very questionable if there is much value in such a plan, and it may be taken for granted that in a general way all transparencies should read from the inside of the car.

Contracts for Tram Advertising. The system of advertising in tramcars is to contract for so many cars in so many towns for so many years. An annual charge is made per car, and for good contracts the corporations of the various towns or their agents will prepare, free of charge, all plates and transparencies needed, submitting proofs for approval. As to the relative values of whole cars or parts of cars, each advertiser must decide for himself. There is much to be said both ways, and naturally a good deal depends upon the commodity and the circumstances of the campaign. When six or more whole cars are taken, an extra car can generally be obtained free, and where a tramcar scheme is in view the agents are generally willing to prepare and give a trial car for a time free of charge. Such free advertising, where a

tramcar scheme is going to be adopted, should be taken full advantage of.

After the advertisements are all in position, they must be carefully examined from time to time, to see that the transparencies are untorn and the plates clean and unchipped. This inspection takes a good deal of time, as a rule, for it is difficult to catch all the cars in a limited space of time unless the sheds are visited in the very early hours of the morning. An arrangement is usually made that not more than one car bearing a firm's advertisements shall be laid up for repairs or repainting at any one time. From time to time the announcements may be changed, but this must not be done too often, on account of the cost of preparing new plates.

Omnibuses. Similar advertising is carried out in connection with omnibuses, both motor and horse; and as these vehicles are generally owned by private companies and not by municipalities, they are less particular about restricting the amount of advertising to be done. In most cases every available spot is used, both inside and out, as a glance at any ordinary motor-'bus will show. While enamelled plates are almost invariably used for the staircases and smaller positions, posters printed on paper of the right size are very often used for the sides of the 'bus at the top. In cities and large towns, theatres and big drapery houses are very partial to these outside positions on the sides of omnibuses.

Tram and Omnibus Tickets. If mere circulation were everything, then advertising on the backs of 'bus and tram tickets would be the first and foremost of all methods of publicity. Unfortunately for the simplicity of the business, circulation in such a case is far from being everything, for while a firm's announcements may appear upon a series of, say, ten million 'bus or tram tickets, vast numbers of these, though placed in the hands of passengers, are never read at all. After riding in a vehicle once or twice and watching the people, and seeing how persistently they all seem to ignore the reading matter on their tickets, it might seem that such a method of publicity was worth very little, but, as in the case of all other media, the true test is the sales effected; and those who use tram and 'bus tickets in a large way declare that the results are good. The statement must, however, be qualified by the remark that only certain articles of very general use should be advertised in this way, and the publicity must be supported by other methods. The tram or 'bus ticket is at its best, from the advertising point of view, when it is being used merely as a reminder of the name of some article of household use, some well-known tobacco, or a popular drink.

Stamp Books. Though in another sphere, the publicity obtained from announcements in books of postage-stamps is on somewhat similar lines to that of tram and omnibus tickets. This is a comparatively new medium, but it is popular with advertisers, and may be said to have justified itself by results. Here advertisers are limited to a very small space, as in the case of the ticket, and the printing has to be in the one colour, green, which is used for the interleaves. Here, again, mere circulation figures are of little value as a criterion of value, for there is no doubt that great numbers of the people who buy the books never look at the advertisements. In regard to these little books, it is probably true that the back cover is of more value than any other part.

Showcards. When we come to showcards we are dealing with a very important branch of advertising, one on which our great manufacturing firms spend hundreds of thousands of pounds every year. A great army of artists, lithographers, printers, and so on is engaged in doing nothing else but turning out showcards, and much real artistic gift and mechanical ingenuity are now brought to bear to make these worthy representatives of the firms that issue them and of the goods they represent.

So much care is given to this matter nowadays that it may almost be said with truth that the majority of showcards are comparatively good, but every firm is striving after something that is more than good, and every now and again it gets it. Sometimes this comes by a happy inspiration. The advertising manager or a colleague hits upon a novel idea, and a first-class commercial artist catches the inspiration and carries out the idea to perfection. Sometimes an artist belonging to a printing firm strikes an idea and carries it out, and when this is shown to some likely firm the advertising manager realises at first glances that this is the very thing he has been looking for.

Designs for Showcards. Different advertisers have different ideas for showcards; and while some will lean to pictures that, though beautiful and attractive, have no connection with the article or commodity advertised—as, for instance, a beautiful Swiss lake and mountain scene for a brand of whisky—others avoid fancy pictures, and get something more directly connected with their goods, as, for example, a mass of fruit or an orchard for a jam. There can be no doubt that, from the advertising point of view, the latter is the better scheme.

In every showcard the picture should tell the story independently of the wording, for the impression gained through the eye, though often unconscious, is pretty certain to last. The beholder will not reason out from a picture of magnificent fruit and a beautiful orchard to jam made of this very fruit, but she will quite unconsciously connect up the things, and the particular brand of preserve advertised by the design will always remain connected up in her mind with fine fruit and a delightful country scene. There is no need for a picture that tells the story to be ugly. If necessary, the figure of a beautiful girl can always be introduced, but in doing this care must be taken that the subsidiary part of the picture—subsidiary, that is, from the advertising point of view—is not so attractive as to hold all the attention of the spectator, and thereby to detract from the main object. Wherever possible, the article advertised should be shown in facsimile somewhere on the showcard.

Distributing Showcards. The old method of distributing showcards was very wasteful. They were sent out to every purchaser of the goods, quite independently of whether he wanted them or whether there was any likelihood of his being able to show them. No matter how artistic or costly they were, at least 50 per cent. were generally wasted. Up-to-date firms do not do this now. They give an opportunity for every customer to indicate, either on an order form or a special slip, or through the traveller, what showcards he can make use of; and it may be taken as a general axiom that if a shopkeeper asks for a card he will exhibit it.

It must not be supposed, when the cards are bought and paid for, that that is the end of the expense. They have to be sent out, and for

this purpose strawboard packing is needed if the cards are to arrive at their destinations in anything like presentable condition. Then there will be freight or postage unless they are sent in the cases with the goods they advertise. This raises the question of the size of showcards. They should not be so large as to be ungainly, and, unless the cases in which the goods are packed are very small, should be made of such a size as to go in these. On the other hand, they must not be too small, or they are apt to look mean and give a poor impression of the goods they describe. By placing them in the case with the goods, not only the separate freight will be saved, but also the packing, or, at any rate, a large proportion of it.

Rectangular Cards versus Cutouts. While rectangular cards are very good, and may be made extremely effective, cutouts are still more attractive, and an enormous amount of real ingenuity and inventive genius is being expended in producing cutouts that are new and clever. A number of points must, however, be borne in mind when ordering cutouts. In the first place, mere cleverness alone should not decide the matter; for while an ingenious contrivances may be excellent when the card is handled carefully in an office, it may be too complicated or intricate for adoption in a cutout that is to go out by thousands and be handled by shop assistants who will possibly exercise very little care in fitting it up for the window. For this reason, the less complication and fitting together of parts, such as slipping strips into slots, etc., that is required the better.

In the second place, care must be taken to see that any secondary parts, struts, tapes, etc., are firmly attached, and will not come apart with a little handling. There is nothing more annoying to the shopkeeper than to receive a cutout which requires adjusting, and as soon as he begins to get it ready for the window or counter he finds that it breaks or comes unstuck. He will probably at once pitch it away, and the shilling or so spent by the manufacturer is simply lost.

In the third place, when ordering a cutout, we should endeavour to select one that has no parts connected with the main body merely by a very narrow isthmus, as, for instance, a hand holding a box connected with the body by a very narrow wrist and arm. The least knock will break a cutout of this kind, and it is at once useless. The difficulty can always be got over in the design by a rearrangement of attitude or clothing, or in some such way.

A fourth point to remember, in ordering a cutout, is to have one that will pack easily for despatch. Most designs can be simplified, and it is well to remember this when considering a cutout. Finally, a fifth point that should not be overlooked is the substance of the card. There is sometimes a temptation to cheapen the cost of the cutout by reducing the substance of the card on which it is mounted, but this is penny wise and pound foolish, as not only will the card warp far more easily, but it will crack with a slight knock or blow. So much for the cutout as a practical advertising medium. Many an ingenious design is planned, and looks very well in an office, as already explained, but we must bear in mind the practical considerations set forth.

Dummy Packages. Connected with the subject of showcards is that of dummy packages. These prove very useful as advertising devices, particularly where perishable goods are concerned, which would deteriorate by exposure to light and sunshine in a shop window. The dummy packages may be just the ordinary labelled boxes or jars or tins in which the goods are packed, or they may be facsimiles of piles of these in the nature really of cutouts, or they may be giant facsimiles or imitations of the packages—as, for instance, a condensed milk tin as large as a dustbin. A good many advertisers, however, hold that though the giant facsimile is striking, and may attract attention, there is nothing better than to familiarise the public with the actual packages which they buy or are expected to buy. For this purpose the boxes or jars or tins themselves are regarded as preferable, or, as a second-best scheme, cardboard facsimiles, such as all the first-class lithographic printers now turn out.

Models and Figures in Windows. A growing practice by keen shop and store keepers is at certain seasons for them to do out their windows to represent some scene connected with their business—a fishing scene for a firm dealing in canned salmon, sardines, etc., or a jungle scene for those dealing in furs. For these, stuffed animals, properly dressed, lay figures, and model trees, boats, etc., are used. The plan is good as an attraction, but the danger is to leave it at that, whereas the plan should be to let it be not merely an attraction but also an advertisement of the goods. This is effected by connecting up the scene with the articles, by having these displayed prominently at the sides, in the front, or somewhere naturally in the scene itself.

Working Models. Working models are very good as attractions, and always draw a crowd, but here again there is a danger of letting the models be independent of direct advertising, and thinking that if a crowd is attracted to the window the whole business is done. A moving windmill, for example, would be very good in connection with a particular brand of flour or bread, but it should be surrounded by bags of the flour or loaves of the bread, and should have prominently printed on it somewhere the name of the flour or the manufacturer, as the case may be.

Billposting. Leaving the showcard and its allies, we now come to billposting, a form of advertising that has made great strides of late years. It is a somewhat expensive form of publicity, but a very effective one, a form that has for half a century or more proved its worth. The strides of recent years have been not so much in the direction of quantity as in the way of quality. Some of the greatest businesses of the day began their advertising a quarter or half a century ago on the hoardings of London and other large cities. The hoardings are nearly all in the hands of a few large firms in each town, which simplifies matters from the advertiser's point of view; but when planning a campaign and selecting the stations very great discretion must be used to choose those that shall be in neighbourhoods where the article advertised is likely to sell, or through which large numbers of the people who may buy it will pass. Obviously, every poster in a poor district advertising an expensive table-water would be sheer waste, while to advertise a cheap margarine in the best part of Belgravia would be equally foolish. The whole matter is one for the exercise of care and common sense.

If any proof were needed that poster advertising pays, the great recruiting campaign which raised an army of millions in a few months entirely by the voluntary principle would be proof enough, for this army has been gathered together more by poster

appeals than by any other means. Even the newspapers—which sometimes talk as though newspaper advertising were really the only form of publicity that counted—invariably use the hoardings when they wish to reach the public with some big, new proposition.

Localisation Value of the Poster. One of the great advantages of poster advertising is its adaptability to localisation. Better is it for such a purpose even than a local newspaper, for the latter always has a certain amount of circulation outside the actual district to be worked, which is therefore wasted advertising, whereas the poster can be confined absolutely to any district, however large or small it may be. Not only so, but while the newspaper will not be read by everyone in the town, the posters—if well placed—will be seen by practically all the inhabitants.

Designs for Posters. During the past twenty years there has been a revolution achieved in poster design. Formerly the crudest colouring and pictures were considered good enough for the walls, but now some of our best artists design the posters that advertise our leading household commodities, beverages, theatres, and so on. It must always be remembered that a poster design must be considered on its own account, quite independent of other forms of advertising. In other words, what will make an excellent showcard or cutout, or cover design for a folder, will not necessarily form a good poster.

Posters should always be pictorial, and the picture should invariably tell the story so that if the observer catches nothing but the name of the firm, or proprietary article or trade mark, on the bill he will nevertheless, from the picture which leaves a mental impression, carry away some fact or thought that shall be to the advantage of the article advertised. No hard and fast lines can, of course, be laid down, but a glance at any of the fine hoardings which are to be seen all over our great cities and towns will reveal the kind of poster that is most effective.

Humorous Posters. And here a word must be said about the value of humour on a poster. Here, more than anywhere, perhaps, in the whole range of advertising opportunity, is humour permissible and advantageous. As Mr. John Hassall, a master in the business, has well said: "The majority of the advertisements which are remembered will be found to be humorous. This shows how valuable they are in attracting the reader's attention. For that reason you will find that most of the advertisers spending the greatest amount annually use humour very largely in their appeals to the public." The humour must be fairly obvious. If it is subtle, it will be beyond the conception of the average passer-by. And it need scarcely be mentioned that it must not be in any sense vulgar.

Simplicity the Essence of Success. Simplicity is the essence of success in a poster. Anything complicated, either in the way of design or of idea, should be avoided. The first requires a long examination to unravel its meaning, and the latter needs an effort of brain that few people will take the trouble to make. The wording, too, must be very short, very plain, and very simple. The less said on a poster the better. "You cannot put much argument on a poster," says Mr. Hassall. "In fact, the sole purpose of the poster is to familiarise the public with the name of the article. The name must be arranged so as to be clearly seen in connection with the picture to which it belongs, and it should not be placed where it might seem to belong to some other poster. One very important thing about a poster is that it should really advertise the intended article, and not something else."

Except in the very rarest cases, the idea should come first, and the poster be designed to illustrate the idea, otherwise there will not be the concerted emphasis which is necessary to make a poster really successful. In this respect the artist has an opportunity which is not so well open to the photographer. A writer has said: "The drawn advertisement pictorially is always able to tell its story, not only much more decisively than the photographic illustration, but much more quickly. And in advertisements it is time that marks the efficiency of the announcement all the while. The copy that 'gets home first' is making an impression that will, for the time being at least, exclude others. Designers of posters and of other advertising illustrations are beginning to realise this. The successful poster is the one in which there is this concerted emphasis. It takes its point, holds it well in front, and presses it home. The other portion of the poster is merely a foil to it. In the poster this is imperative. The poster which neglects this factor—and there are many—is almost wholly wasted effort."

Sizes of Posters. The unit of measurement in posters is the double-crown bill, which is 20 in. by 30 in. It is the size of the ordinary newspaper bill seen outside the newsagent's shop every morning and evening. All other sizes in posters are multiples of this, and are spoken of in terms of sheets. Thus, one double-crown poster is spoken of as a single-sheet bill, a poster twice that size, 30 in. by 40 in., is a two-sheet bill, and so on. The double-crown bill is the unit, and this must be remembered. Of course, the big poster is not made up of the number of sheets which its name would imply. For example, an eight-sheet bill may be printed in two sheets, and would not, in any case, be in eight parts. The sheet refers to area, and not to number.

Cost of Billposting. Billposting can, of course, be experimented with or tried on any scale, large or small. "Covering the country," says Mr. Cyril Sheldon, "is one thing, but entering upon an ordinary billposting campaign is quite another matter. Suppose an advertiser was broad-minded enough to wish to discover for himself by means of a practical experiment whether the use of posters was suited to his business or not. This need not be such a heartbreaking matter. For an expenditure of about £350 a trial campaign could be made in an area embracing a population of about a million. This would allow for the posting of a sixteen-sheet double-crown (120 in. by 80 in.) bill in suitable quantities in each town in the area for a period of three months, together with the necessary bills, well printed and designed by a good artist. This would be an expensive experiment, in that the number of bills required would be so few, and those few would have to bear the whole cost of the original design, and the putting on to stone, whereas if the bills were part of a general order for printing, the cost would be reduced at least £50.

"It would not be at all difficult to select an area where the cost of posters is lower than the one allowed for, making a consequent decrease in the cost of the experiment, but it is not desired to put the case on the lowest possible basis, but rather on an average basis. There is a good deal of talk about 'circulation' at the present time; and if billposting were to be judged by that test, and judged with fairness, there would not be sufficient hoardings in existence to accommodate the inrush of posters

there would assuredly be, for it must be remembered that the £350 covers the cost of exhibition, not for one day, but for ninety-one days, and there is no 'circulation' to be had anywhere else within a gunshot of this for economy."

One other point must be mentioned in connection with billposting, and that is the importance of proper checking while the bills are up. Even billposting firms may make mistakes, and therefore the advertiser should always have a competent person go round from time to time to see that the posters are duly put up in the selected positions, and that they are all in a presentable condition. The life of a poster varies tremendously. In dry weather, on a fairly high and protected position, it will be considerable, but if the bill be posted where mischievous boys can get at it, to tear it or to scribble upon it, it will be mutilated almost as soon as it is up. This should be borne in mind in selecting sites. In wet weather, of course, posters have a bad time, although there are now waterproof pastes and water-resisting papers.

Electric and Illuminated Signs. Signs that are lighted up at night, or that change letter by letter by the lighting and extinguishing of electric lamps, are very popular forms of advertising, and in crowded thoroughfares with wide vistas are very effective. They may almost be regarded as night posters, and their advertising value is perhaps more than that of even the artistic picture poster, for, being fewer in number, they attract more attention. They are, however, expensive, and should only be used as supplementary by a big advertiser, or for a definitely local purpose.

Cinema Advertising. The growth of the picture palace during recent years has led to its utilisation for advertising purposes by many of the large manufacturers of household commodities. The method in favour up till quite recently was to have a film illustrating the manufacture of some article, such as cocoa, jam, etc., but the popular taste finds such exhibitions rather too heavy as part of a general entertainment, and more lively or subtle methods are now in vogue. One plan is for the article that is to be advertised to be introduced into the scene of some ordinary humorous film. A box of a well-known breakfast food or a brand of some well-known brand of jam is standing on a table, while the characters carry out their acting. More elaborate is the humorous film given up entirely to the article. A box of chocolates, for instance, appears on a table, the lid opens, the sweets jump out, dance about, form faces and other designs, and then form into the name of the manufacturer. They then spring back into the box, it closes, and dances off the screen. This ends the film, but people who have seen it describe it to their friends, and in doing so can hardly fail to mention the brand of chocolate.

These trick films, before the war came very largely from the Continent, particularly Germany, and the objection to many of them has been that, where figures were introduced, these had a very foreign appearance. It is safe to say that this style of advertising has come to stay, and there is no doubt that the films will be more than ever prepared in this country.

The principal danger always to be guarded against is that of vulgarity. Many of the films are humorous, and it is very easy for humour to become too broad, an expression of the face, a gesture, making all the difference between that which is legitimate and that which has a cheapening effect upon the article advertised.

Making the Best of the Cinematograph. This, however, while wonderful and likely to be talked about, is not the best kind of advertising film. As an illustration of how well the moving picture may be made to tell the whole story about a household commodity, the following example will show. It was one of a series of films shown at a demonstration, and represented a well-known flour. The title of the film was "The Cook's Dream," and in it the cook made a cake in the ordinary way with ordinary ingredients, but the result was a sad failure. Tired and disgusted, she sits down and goes to sleep beside the utensils, and, while she sleeps, a girl, wearing a check apron, comes in, and with the proprietary flour makes a cake with no trouble at all, with smiling cheerfulness, and completes the work in a few minutes. The directions which she followed are thrown upon the screen. This, briefly, is a description of the film, and a little consideration will show how excellent it is. The amusing story holds the attention of the audience, and all through there is expectancy as to what will happen next. Then the girl who comes in while the cook sleeps wears the check apron with which the public have been familiarised in Press advertisements of this particular flour. Her action and its results give a practical demonstration of the value of the flour, and the directions and phrases thrown on the screen drive home the lesson.

Theatre and Concert Programmes. Another advertising medium much used, which is also connected with places of popular entertainment, is the theatre or concert programme, but it is a question whether these are of much value, except for alcoholic drinks, cigars and tobaccos, and similar advertisements. These are the articles that are generally advertised on programmes; and it must be confessed that, so far, the manufacturers of household commodities, the mainstay of advertising, have not used this media extensively. In a general way, programmes are not any too attractive, their form is not suitable for the display of advertisements, the settings are not usually good, and it is a question whether people at theatres and concerts are in the frame of mind in which a lasting impression can be made upon their minds by something that is concerned with their everyday life. They have gone to the place of amusement for relaxation and entertainment, and, despite the fact that they may have to sit waiting half an hour or so for the performance to begin, it is doubtful if they read the advertisements on their programmes, and, if they read them, whether they think about what they read. Anyway, only the spaces round the actual programme should be taken; those on the back are of very little value indeed.

A suggestion has recently been made by Mr. J. Peile that programme advertising can be made much more effective by a change in its form. He maintains that, as people go to theatres and concerts mainly to be amused, the advertisements on the programmes should be cast in a humorous vein, and would then find the people responsive. This is done in France, and there seems no reason at all why it should not be attempted here. The agents for letting space on the programmes would, however, have to take the first step to organise the business, for it would be little better than useless for one or two firms to attempt this. If the services of some able humorous artist, such as Mr. Hassall, were enlisted, and the advertisements systematised, the programme might be saved for its humorous advertising pictures.

Fancy Costumes. While on the subject of popular amusements, another form of advertising may be mentioned. Manufacturers often get applications from people, both male and female, who are going to fancy-dress balls, and wish to go in a costume illustrating the commodity that the manufacturers are noted for. It is not necessary for the manufacturer to have elaborate costumes made up to lend out, but by supplying showcards, cutouts, cartons, and labels he can very often get an excellent advertisement; and if the costume wins a prize, the name of the firm whose goods are represented will probably be mentioned in the local paper. For example, at a recent fancy-dress ball, two costumes represented Chivers' jams and canned fruits, and these were made up from showcards illustrating sprays of fruit and a number of labels with pictorial representations of the various kinds of choice English fruits packed. So excellent was one of the costumes that it took a leading prize. The body of the dress was a grey silk, and the pictures were arranged artistically round it.

Hotel Advertising. A good deal of advertising is done in the large, popular hotels. This is generally effected by means of framed cards over the mantelpieces in the bedrooms, each card being divided up into a number of spaces that are let to advertisers for a period of one, two, or three years, an annual rental or a lump sum to cover the period being charged. It must be remembered that the hotels that do this are not the great, high-class hotels, and therefore the class of people who frequent them are not the wealthy. But for a middle-class clientèle they are excellent, and there is no doubt that the spaces are of considerable advertising value.

The menu-cards in the dining-room and in restaurants are also used as advertising media, though it is a question if these are of much value. The advertisers are usually the firms who supply goods to the hotel or restaurant, and who take the space somewhat in the way of a quid pro quo for the business they receive.

Lantern Lectures and Slides. A good deal of excellent advertising can be obtained by many manufacturing businesses through the medium of the magic lantern. It is surprising that a larger number of firms do not use the opportunity thus provided. A series of slides showing the various processes of manufacture, from the gathering of the raw material to the issue of the finished product, can be prepared at very small expense, and the cost of multiplying sets of these pictures is not great. The slides can then be let out free of charge, any breakages being charged for, and carriage both ways being paid by the borrower. Of course, if the best value is to be got out of this form of advertising, a consecutive lecture must be prepared to go with the slides. The usual plan is to make the matter quite subsidiary to the slides, mere descriptions of the pictures; but not only is this ineffective from the advertising point of view, but it also detracts considerably from the interest.

A thoroughly connected lecture should be written, the pictures coming in merely as illustrations incidentally. The lecture must, of course, be light in style, with a vein of humour, if possible, running through it; and prepared in this style, with a set of about thirty or forty pictures, it will be welcomed by clergymen, schoolmasters, and others, particularly in villages and rural districts that are very difficult to reach with advertising in other ways. The mistake so often made is to give far too many slides in a set. They are rushed through the lantern with the briefest of descriptions, the eye is tired, the mind is confused, and no definite impression is left on the brain, so that the whole lecture, and probably the article whose manufacture it illustrates, is soon forgotten.

Advertising Novelties. A great deal of money is spent by advertisers on little novelties, printed in colours on card and made either in the form of working models, more or less elaborate, or in the form of a game, painting-book, or some other toy interesting to children. These are very good as supports to other advertising, such as that obtained through the Press or poster; but novelties are expensive, their distribution in right channels without waste is not easy, and their advertising value is not very direct. They do little more than give a reminder of the name of a firm or commodity. The usual methods of distribution are through the shopkeepers, by house to house distribution with samples, and through the elementary schools, which are always anxious, particularly at Christmas-time, to get such novelties for the children. A little ingenuity will suggest novelties that need not cost more than a farthing each; and it is safe to say that the less complicated they are, the better they are from the advertising point of view. Elaborate working toys that easily get out of order have a very short life, and they are naturally far more expensive than the simpler novelties, which not only last longer, but, being cheaper, can be distributed on a more wholesale scale.

Useful Gifts. Gifts for distribution need not be confined to novelties of this elementary type. Some businesses find it good advertising to give away in certain quarters more costly and useful gifts, such as pencils, penknives, pocket-books, diaries, pocket-mirrors, etc. And the name of the firm bestowing them should not be too obtrusive on the gift, or it will miss its purpose. Few people care to use a knife or pencil, etc., that is obvious to all beholders as an advertising medium. These useful gifts are usually distributed to shopkeepers' assistants, buyers, and others, and are intended to act as reminders of the firm that gives them. Of this type of advertising medium, the calendar is the most familiar. An enormous number of firms issue almanacks in all forms, shapes, and sizes, from the pocket calendar, the desk calendar, the large or small diary, to the artistic wall almanack printed on card or paper.

From an advertising point of view, the tear-off calendar, with a different sheet for each day, is by far the most useful. On each sheet there can be some fact or phrase about the article advertised; and not only will the changes be rung, but the very fact that the words change from day to day will ensure that they be read by most people who see a use in the calendar. It has been pointed out that while a page in a daily newspaper costing £250 will bring an advertised article before about 850,000 people for one day only, 15,000 calendars, costing the same amount of money, will have a life of 365 days, the circulation therefore reaching 5,475,000.

Household Articles. Of this class of advertising medium is the household article which is given away to advertise some commodity in the consumption of which the article can be used. A salt-sprinkler given by a salt firm, a jam-dish by a manufacturer of fruit preserves, a toothbrush by a tooth-paste manufacturer, a saucepan by a

purveyor of prepared oats, and so on, are actual examples of advertising of this class. The article, of course, bears the name of the firm, and every time it is used it is a reminder of the goods it advertises. It must always be borne in mind, however, that publicity of this kind must not be too evident, or it will defeat itself, for people will not use an article that is too obviously intended as an advertisement.

Other useful articles that are serviceable in shops, such as counter-mats for the cashier's desk, umbrella-stands, water-troughs for dogs, and so on, are a good deal used as advertising media ; and they are quite good, for they serve the double purpose of pleasing the shopkeeper and keeping the particular line of goods before his notice, and of advertising the goods also to the public who go into the shop.

Advertising on Delivery Vans. A form of advertising that has grown up quite recently is that of placing announcements of goods on the sides of delivery vans. Practically all the large firms of carriers now let out van space in this way; and there is no doubt that, in London particularly, the publicity obtained by those using the spaces has been good. But apart from the carrier firms, every manufacturer who has delivery vans of his own will utilise the spaces on the sides for advertising. The announcement will have to be very brief, and in selecting a colour-scheme something original should be sought, though not so original as to be inartistic. Such advertisements, if they are to help and not hinder, must be kept in good condition, being repainted whenever necessary. Nothing is more harmful to a first-class firm than a shabby advertisement. The sides of the van are, of course, the most obvious places for an advertisement ; but it must be remembered that far more people see the front and back of a van as it comes towards them or goes from them than the sides, and therefore there should be a prominent announcement on the shade over the driver, which can be read by those who see the van coming, and a similarly distinctive notice on the back, for the benefit of people after the van has passed them going in the same direction. Further, as there are many millions of people travelling on the tops of omnibuses and trams, who are constantly looking down and cannot see plainly the sides of a van immediately below them, it is worth while to paint an announcement neatly on top. The mere novelty of the thing would attract attention and secure excellent publicity. The wonder is that this has not already been done on a wholesale scale.

Aerial Advertising. Probably the advertising of the future will be aerial advertising. Already a good deal of this has been done by means of fixed balloons, floating banners attached to box-kites, and so on. But the aeroplane opens up endless possibilities in this direction. It can go where it will, always attracts attention ; and if an announcement in large letters is painted on the under side of its wings, it could be read quite easily when the machine was travelling at a low elevation. With the perfecting of aeroplanes the restrictions about flying over towns will no doubt be relaxed, and we may expect a much greater use of the medium than there has been during the past few years. Even more effective than aeroplanes may be air-ships, owing to their larger size; and there is no doubt that the attention of manufacturers and others will soon be turned in this direction.

House Magazines for Retailers. House organs for manufacturers have already been referred to, but it is not only the large wholesale firm or the great manufacturer who may successfully make use of a house organ. The retailer, if he is in a fairly good way of business, may also have his magazine, while even smaller retailers, if they combine together, may run a local magazine that may prove of untold advertising benefit to them all. Their plan would be to form a little syndicate, arranging that each trade—grocer, tailor, jeweller, etc.—should be allowed to participate. There is even room for some enterprising individual to produce a really first-class magazine for localisation by shopkeepers, just as similar magazines are produced for localisation by the Churches. A group of traders in each town could then arrange for the printing of a local cover and insets, with space given up to the advertisements of each. If the magazine was produced in really good style, and had first-rate stories and articles, it might even be sold for a penny, so that the retailers would get some of their money back.

Such a magazine must be essentially a domestic magazine, for it will be read only by the women of the house ; and, of course, it must have pages for the children. One or two large firms in the United Kingdom already issue excellent house magazines on their own account, and recoup themselves largely for the outlay by letting space inside at substantial rates to the manufacturers of proprietary articles. The house magazine may be distributed in the shops of the firm, or, better still, it may be posted, like the catalogues, in envelopes to the addresses of customers and other suitable persons.

The principal forms of advertising have been dealt with briefly, but there are, of course, many other media which have not been touched upon, and these are constantly growing, for with the coming of new ideas and new inventions it is not long before the novelties are harnessed to the purposes of publicity. The advertising man, if he is to be successful in the best sense, must not be one who merely does what others have done before him, however well he may do it, but one who is always on the look-out for fresh sources of publicity, and who—at times, at any rate—is the first in the field. The status of advertising is certainly being raised, and its vital importance was never so realised as it is today. That importance will grow with the years, and there is no doubt that in the future there will be more, not less, publicity.

Entering the Advertising Profession. In view of this, it may be interesting, in conclusion, to say a word or two as to how the profession of advertising may be entered. Like journalism, it is a profession for which a man—or a woman—must have a natural instinct ; and just as the successful newspaper man will have "a nose for news," so the successful advertising man will see in all kinds of incidents and happenings an opportunity for obtaining publicity. But apart from this, there are, of course, certain routine matters that have to be learnt by practice; and the best thing a young man who has ambitions in the direction of advertising management can do is to seek a position on the staff of a firm of reputable advertising agents, or in the publicity department of a large manufacturer. Even if he desires to take up the newspaper side of the work, a training in an advertising agency will be of inestimable value.

CHARLES RAY

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Veneering. Inlaying. Furniture Construction. Table Tops. Carcases. Fitting of Shelves, Backs, and Tops. Framed Work. Staining and Polishing.

CABINET-MAKING

No sharp distinction can be drawn between cabinet-making and joinery, any more than between carpentry and joinery, though in each case it is easy to give specific instances of work that is within the exclusive province of one or the other. Joinery occupies an intermediate position, and is overlapped at one extreme by the rough and heavy work of carpentry, and at the other by the fine and neat work of cabinet-making. Such work as plain furniture, and shop, bank, and office fittings may be done either by cabinet-makers or joiners, the choice depending chiefly on the degree of finish required. With the exception of plain deal articles the construction of furniture is regarded as cabinet work. With a few exceptions the tools employed and the methods of jointing have been described in the courses on Carpentry and Joinery.

Woods Employed. In cabinet-making, hard wood is chiefly used, and the soft varieties, in which the bulk of carpenters' and joiners' work is done are generally used only under veneer and frequently not even then. A great number of fancy woods are used, but for large articles the list is very much reduced owing to the unsuitability or cost of many of the rarer woods. Mahogany is the most commonly employed and is one of the best for furniture, owing to its small liability to shrink and warp. For many years after it came into general use it was to the cabinet-maker what oak was to the carpenter, and what deal is to the latter craftsman at the present time. There are two main varieties, the Spanish, which is valued for its rich appearance and hardness, and the Honduras, or baywood, which is softer, straighter grained, lighter in colour, and cheaper. The chief other woods used are oak, walnut, ash, and birch. The important woods have been described in the chapter on the Strength and Use of Timbers, beginning on page 211. Soft woods, such as pine and American whitewood, are used a great deal for parts that do not show, such as backs of carcases and drawers, drawer bottoms, runners, and sides. They are used also covered with veneer, or in some cases—drawer bearers, for instance—may have a hard wood facing about ½ in. thick, glued on the front. All wood in cabinet work must be thoroughly seasoned. Artificial drying in kilns is usually resorted to. There are many varieties of these.

Furniture Designing. This is not done by the journeyman cabinet-maker, but by specialists, who make the drawings for him to work from. These drawings are usually not very elaborate compared with the drawings required in some other trades, for exact dimensions are unimportant, and many details of construction can safely be left to the judgment of the workman or his foreman. A single perspective view of an article with its leading dimensions is therefore often sufficient for a cabinet-maker to work from, and in some cases no drawing at all is made. Drawing is supplemented a great deal by written instructions. The designer must be familiar with methods of construction, or he will cause needless trouble and expense, with perhaps weak and unsatisfactory results. Apart from this, he is chiefly concerned in designing goods that will best command a sale. So much variety has gone before that new designs now are new combinations of features of old designs. It might be quite possible to design something absolutely new, but the demands of utility and good appearance would almost certainly condemn it. The first essential in any article of furniture should be a design which makes it convenient for use. All ornamentation and considerations of appearance should be subsidiary.

The Value of Appearance. In cabinet work appearance has to be considered more than in other woodworking trades, and though utility should never be subordinated to it, it makes a difference between the work of the cabinet-maker and that of the joiner and carpenter. Good work is desirable throughout in an article of furniture, but only parts that are constantly visible are finished neatly, while backs and under parts are left rough. Another thing peculiar to cabinet work is that strength is in most cases of less importance than appearance. Furniture is not supposed to be subject to rougher usage than when serving its normal purpose, and the cabinet-maker constructs it on that assumption. In the jointing of light framework, for instance, stub tenons or dowels secured by glue alone are typically cabinet work. In many articles, however, the appearance of strength is desirable, and thus we have pilasters formed by gluing thickening pieces against thin sides, and the lining-up of horizontal pieces, and addition of solid-looking plinths and cornices. In some cases the purpose of an article permits of great latitude in fixing dimensions, and then proportions are adopted which look well. Thus an article of rectangular shape is not made more than twice as long, or high, as it is wide.

Changing Fashions. The design of furniture is subject to slow changes of fashion. As with dress, and other things, the style of which changes without necessarily improving, this is caused by a desire for distinction among wealthy people and desire among poorer ones to imitate them, a new fashion being adopted by the former as soon as the reigning one has become common property. Besides this, public taste varies at different periods, and the style of furniture varies correspondingly. It is possible, however, that the changes of the future will be slight compared with those of the past, because extremes in all directions have been reached and recognised as unsatisfactory. The best furniture is made primarily to serve its purpose perfectly, and secondly, to please the eye. The highly ornamental and the severely plain, alike, generally fail in both these directions.

A complaint frequently made is that furniture is less substantially made than formerly. The assertion is less true now than it was some years ago, but the time has gone past when quality and methods did not vary much from a set standard. If the best work now is not superior to any that has ever been done before, it is because better work is impossible. No one can dispute that a great deal of modern work is trashy, but as such work does not last we have no

means of knowing whether the workmen of a century or more ago were equally skilful in that direction. Probably they were not. The rank and file, no doubt, were ignorant, simple-minded men in a position to take as much time as they pleased to do anything. They had a high opinion of their manual skill, and exaggerated notions of the importance of trade secrets, in many cases not to be imparted freely to each other, and still less to the outside public. Modern conditions are different. Work is done now much more expeditiously and consequently at comparatively far lower prices. In many cases the cost of labour is a trifle compared with the cost of material. This is not because wages are low or because manual work is done more rapidly than formerly. It is because the workman now is assisted by machines which perform all the operations that before occupied most of his time. The subdivision of labour now prevailing also conduces to rapidity of production.

Old and Modern Work Compared. Neither machine work nor subdivision of labour means inferior work, but rather the contrary. In some respects the best of the very old work was rough compared with the best modern work, and its roughness was not compensated for by its being any stronger than what is made now. We have only to notice the construction of old furniture preserved in museums to perceive that. Articles elaborately carved and inlaid are often jointed more roughly than would be permissible now. The use of wood pegs in tenoned joints, with the end grain of the pegs showing in the front faces of the work, and generally projecting about a sixteenth of an inch through shrinkage, would be intolerable in the cheapest modern articles. Old work suffered also through being done by men who were not specialists. There are few men who can do both heavy and light work with equal accuracy, and no one man can be as skilful at half a dozen classes of work as the same number of specialists assisted by machinery can be.

The Element of Time. If it be untrue to pretend that our best is not equal to the best that has gone before, it is still more untrue to suppose that our men are not equal to their predecessors. Only those whose admiration for the past is based on unreasoning sentiment can believe so. So far as we can judge of them, there is no reason to doubt we not only have their equals, but have far greater numbers of them. But in most work nowadays the element of time has attained an importance it never had before. Most classes of work are so often repeated that the time they should occupy is known or can be estimated almost to an hour, and it is to the workman's discredit if he exceeds this almost as much as scamped work is to his discredit. The test of a first-class workman is to do work of the best quality in the minimum time. If an unlimited amount of time is allowed, a far less skilful man can equal the product in quality. A first-class workman, however, has not always the opportunity to do the best work. Quantity instead of quality may be required of him. There is a large demand for cheap articles, the cost of which is cut down by employing inferior material and quicker methods of construction. Their unsubstantial character does not indicate that they were made by incapable workmen, but that their cost was not allowed to exceed a certain amount. Work of this kind is justifiable because it supplies a demand, but in the case of the cheapest work it may be doubted whether the demand would be very great if the average purchaser were capable of seeing its defective character.

Modern Subdivision of Trade. Cabinet-making, even more than most trades which have attained a high degree of development, is very much subdivided. It has first of all two natural divisions, for there is a decided difference between carcase work, such as wardrobes, chests of drawers, etc, which are boxed in, and open framework, such as that of chairs. Chairs are so different to ordinary cabinet-maker's work that people employed in their construction are known as chairmakers, and not as cabinet-makers. Chairs differ so much from each other, however, that the chair-making industry is itself very much subdivided. But even among articles of furniture which do bear considerable resemblance to each other, it is found more economical for firms to confine themselves chiefly to one, and portions of that are often purchased ready made. In no case is all the work on one article done by one person. All turned parts are done by a wood-turner. Carving is done by a carver or by machinery. Veneering and inlaying are done by specialists. Polishing and upholstering are done by men of those trades. Among the operations just mentioned the only ones that can be considered as branches of cabinet-making are veneering and inlaying.

Veneers. These are thin sheets of fancy wood ranging in thickness from that of a thin sheet of paper to $\frac{1}{4}$ in. They are used a great deal in cabinet work, and to a less extent in joinery, for gluing to the surface of cheaper wood to improve the appearance of an article. In some cases also curved parts are built up entirely of veneer by gluing a number of thicknesses together. *Ply wood*, which is now largely used for panels and drawer bottoms, is built up in the same way with the grain of the layers crossed. These, however, are not veneer in the ordinary sense, but plain cheap wood sawn thin. The most expensive furniture woods, and especially pieces of exceptionally handsome appearance, are seldom used for anything else but veneer, for it would be considered a waste of valuable material to use it in any other way unless for articles so small that the amount of material used in them is not worth considering.

Veneer is cut by special machinery, and comes into the cabinet-maker's hands ready for use. It is known either as *knife cut* or *saw cut*, according to the method of cutting it to thickness. By the knife-cut process it can be cut very thin, and there is, of course, no waste in sawdust. From 30 to 40 thicknesses may thus be obtained from 1 in. By sawing, about one-third that number is the most possible, but sawn veneer is thicker and for most purposes, better, though more troublesome to glue. Saw-cut veneer as used for most purposes is about $\frac{1}{16}$ in. thick. Very thin knife-cut is sometimes backed with paper. This prevents it from splitting and warping. Warped veneer may be flattened by damping and putting under pressure between warm, dry boards. Knife-cut veneer may be either sliced or rotary-cut in a kind of lathe. The log is steamed or boiled before cutting, and the cutting machinery is very heavy and rigid, so that a sheet of tissue paper thickness can be cut if desired.

Veneering. The methods of gluing veneer differ in some respects from those of making ordinary glue joints. This is owing to the thinness of the veneer and the large surface to be glued. There are two methods; one by means of *cauls*, which practically means cramping the parts till the glue is set. The other by the use of the *veneering hammer*, which means squeegeeing surplus glue out by sliding pressure on the veneer, and the latter in such cases is always so thin that it remains

in contact without further treatment. This latter, however, is considered only a makeshift method, to be employed when cauling is inconvenient.

The wood on which veneer is to be laid must itself be carefully chosen. A hard close-grained wood does not adhere well to a soft one. Soft woods, such as pine and American whitewood, are very commonly used beneath veneer, but in the best work Honduras mahogany would be employed as a groundwork. Knots should be cut out and pieces of ordinary wood fitted and glued in their place. Small holes should be filled with plaster of Paris. The surface, after being planed, is roughed with a *toothing* plane and sized with thin glue. A toothing plane iron is shown in **1**. It fits nearly vertically into a plane body resembling an ordinary smoothing plane. The serrated edge of the iron scratches the wood and leaves a surface on which the veneer is not liable to slip and the glue obtains a good hold. Two toothing irons of different degrees of coarseness should be kept, as a finer iron is needed for hard wood than for soft. Another method sometimes adopted is to go over the surface with coarse glasspaper on a flat rubber. The veneer is toothed also when sufficiently thick. Rounding surfaces are rasped and roughened with coarse glasspaper. Where a piece of board is cut tangentially to the annular rings of the tree and only one side of it has to be veneered, the veneer should be laid on the heart side, as in **2**.

Veneering with the Hammer. The veneering hammer is used as in **3** and **4**, to press out surplus glue. The hammer has a handle about 1 ft. long and a head about 6 in. square by $1\frac{1}{4}$ in. thick, with a piece of thin iron inserted in a saw-cut in its lower edge and secured by screws. The edge of the iron, which is used to press the veneer, is rounded slightly and made smooth so as not to injure the surface. In addition to this, soap is often used to enable the hammer to work freely without sticking. Hot water is also sparingly applied to the upper surface of the veneer, chiefly to counteract the tendency to curl when it is wetted by the glue on the other side. The glue is spread as rapidly as possible on both the ground and the veneer; the veneer is laid on the ground and pressed down, and then the hammer with heavy pressure on its head is worked about the surface to force as much glue as possible from the centre out to the edges. The easiest way to move the hammer when pressing on it is to work the handle from side to side while moving it forwards or back, thus giving the head a zigzag movement over the veneer. The veneer, as a rule, will remain in close contact after the hammer has been passed over it, but sometimes blisters may be seen or detected by tapping. In such cases the glue beneath may be remelted if necessary by the application of heat, which soon penetrates the veneer. A hot flat iron is generally kept ready for this purpose, and a damp cloth first laid on the place where it is to be applied. The blister will then generally remain down or if it is obstinate a weight may be put on it for several minutes. A bowl of hot water is placed on the bench when the veneer is to be laid, and the hammer, when not in use, is put in the water to keep its edge free from hardened glue. A sponge and one or two pieces of cloth are kept in the water, too. The gluing must be done in a warm atmosphere free from draughts, and the glue applied as hot as possible, so that the veneer may be properly laid while the glue is still quite liquid. Veneer can be removed if necessary by the application of heat and oil or water to loosen the hold of the glue, but it is never worth while to do this, as the veneer would be practically spoilt in the process. Bad places in veneer are better rectified by cutting them out and fitting other pieces in. A piece with grain as nearly like it as possible should be laid on top, and an irregular cut made through both, following the grain as much as possible to make the joint unnoticeable. An inlaid piece cut geometrically square or circular is much more conspicuous. Air can be released from a blister if necessary by making a small puncture. If more glue is required beneath, a slit must be cut with the grain.

Veneering with Cauls. A caul is a piece of wood, zinc, or other material, of the size required to cover the surface to be veneered. It serves two purposes. One is to contain heat to make the glue run freely when it is cramped on. The other is that, veneer being too thin to have any rigidity in itself, uniform pressure must be applied all over its surface, and cramps alone would not do this. When a surface is large, its area may be covered equally well by a number of cauls placed side by side. For curved surfaces, cauls shaped to fit the curve are required, but in most work surfaces are flat, and the cauls are flat pieces of wood of about 1 in. to $1\frac{1}{2}$ in. thick, sometimes kept specially for the purpose, sometimes selected from the stock of wood used for ordinary work. For permanent use they are better covered with sheet metal, preferably zinc. This not only preserves their edges from wear and reduces the risk of splitting and warping, but glue from the veneer does not obtain a hold on it, and consequently it cannot get stuck to the work, as is sometimes the case with wood cauls, for glue makes its way through thin veneer. Another reason why metal is preferred is that cauls have to be heated before they are applied, and, if care is not taken, the wood ones are liable to get spoilt through burning. Neither do they retain heat as well as metal cauls. Small cauls may be merely plates of zinc $\frac{1}{4}$ in. to $\frac{3}{8}$ in. thick. Large ones are backed with wood. Cauls of irregular shape, and consequently troublesome to make, are, if constantly required, usually made of cast iron. For temporary use a bag of sand may serve as a caul on a surface of any contour, and may be heated and cramped on the veneer. Cauls are cramped to the surface by any convenient method.

For small work, hand screws are generally used [**5**], and, as in using the hammer, pressure should be applied first to the central parts to force the glue outwards to the edges. In **5**, two pieces are veneered with one caul between them. Wood cauls should always be soaped to prevent their sticking and pulling pieces of veneer away. Zinc cauls are soaped also when working with very thin veneer. In using cauls, only the dry heat of the caul is employed, and therefore the work is dry and hard in much less time than is required for hammer-laid veneer, in which the surface is wetted with hot water. The cauls and cramps are left on for several hours, until the glue is set. For work on a large scale, metal presses [**6**] with powerful screws are used, and a number of boards with veneer on are put in a pile and very heavy pressure applied, a number of presses, about 6 in. apart, being used to press long pieces. The boards are passed through machines which apply the glue very rapidly. For work on a small scale various kinds of wood presses are made by the workman, the principle being similar to the iron press shown, but wedges, instead of screw power, are the usual method of applying pressure. Joints and cracks in veneer are kept together and the glue prevented from coming

through and sticking to the caul, by pasting paper or canvas over. In some cases it is a practice to cover the entire face of veneer with paper. This is cleaned off after the cauls are removed.

Veneer is cut to dimensions by laying it on a flat surface, using a straightedge on it as a guide, and cutting with a sharp chisel or knife if the veneer is thin, or with a saw if it is thick. Joints on a surface are made by lapping the edge of one piece over the adjoining one, and then by cutting through both. Veneer should always be put on larger than required, and the edges trimmed off afterwards, otherwise there would be trouble in setting it correctly into position while gluing. The best veneer is generally put on panels, because the figure or grain of the wood is more noticeable there than on narrower parts. Often they are *cross veneered*—that is, a plain piece of veneer is first put on across the grain, and this is afterwards covered by the final veneer with its grain running the same way as the *ground* or *core*, as the interior wood is called.

Veneers on panels and other large surfaces are sometimes cut and jointed geometrically, pieces cut out from the same log being turned with grain reversed towards each other, so that similar curls and twists incline to the joint from opposite positions. Parts may be stuck down and pieces fitted in to make bad places good, as described for hammer-laid veneer.

The Scraper and its Use. The scraper is a small piece of sheet steel about $\frac{1}{32}$ in. thick. Its usual form is rectangular, measuring about 6 in. by 3 in. Often a greater length and less width is found convenient, but in any case its original dimensions soon become reduced by wear. Other forms are curved to suit hollow or round surfaces. Its edges are made very keen by first squaring and then slightly burring or turning them over, as shown to an exaggerated extent in **7**.

The scraper is a tool frequently used by joiners, but to the cabinet-maker it is indispensable, and is used after the plane on almost all surfaces. The hard wood used by the cabinet-maker is often too cross-grained to be planed at all without tearing up the surface and leaving it worse than when sawn. But even when it can be planed smooth, the marks of the plane show as a series of undulations across the surface, and although these might be removed by glasspaper on a rubber, it would be difficult to produce as smooth a surface as can be done with a scraper in less time. The scraper, therefore, generally follows the use of the smoothing plane and is itself followed by a rubbing down with very fine glasspaper.

The scraper is held and worked at an angle as in **8** and **9**, so that the sharp edge can be made to scrape or cut a very fine shaving when moderate pressure is exerted. Sometimes the steel is fitted into a wood block which serves as a handle [**10**.]

The sharpening is effected as follows: The edge is first ground or filed square and straight with a very slight amount of rounding up at each end, so that the corners will not leave ridges on the surface of the wood. Next, while still keeping the edge square, it must be made perfectly smooth. The best way to do this is by rubbing it on an oilstone [**11**]. The edge must be rubbed with the scraper vertical on the stone, and each face must also be rubbed [**12**] to remove the ragged burr which gets turned over in grinding and smoothing the edge. The edges should now be square and smooth with sharp angles. It is necessary now to burr or turn these angles uniformly so that they shall be very much keener than they are at 90°. This may be done with the scraper in either of the positions shown in **13** and **14**. Another way is to hold the scraper in a vice. A short rod of steel in a handle is the proper tool to turn the edge with, but very often the back of a small gouge is used for the purpose. In **13** the scraper is shown held in a vertical position with its lower edge resting on the edge of a bench. In **14** the scraper is laid flat on the bench with the edge to be sharpened projecting slightly over. In both cases the sharpener is held at a similar angle in relation to the edge of the scraper. With the sharpener slightly tilted as shown, and pressing as heavily as possible, it is drawn sharply along the edge, turning over a slight burr as it goes. This burr is imperceptible to the eye, but is sufficient to scrape a wood surface far more effectively than would have been possible before this operation. If sufficient pressure is applied, one stroke of the sharpener is enough, but if not, more may be made. The edge soon becomes dull with use and requires re-sharpening, and after this has been repeated a few times, the edge becomes so worn that it is necessary to re-grind. In re-sharpening, the turned edge is generally rubbed flush, as in **15**, before the sharpener is used to turn the edge afresh. All the edges of a scraper may be sharpened in this way so that each can be used in turn till too dull to cut.

Inlay. The inlaying of ornamental design into a surface is frequently practised to decorate cabinet work. To a person unacquainted wth the practice it might be supposed that the effect was obtained by staining or painting the design on the surface. The difference in colour is obtained by the use of different woods, and in a few cases, where such colours as blue or green are employed, by staining the inlaid wood before insertion. Wood is the chief but not the only material used as inlay. Others often employed are ivory, pearl, tortoiseshell, and metal. It is then called *buhl* work. The inlaid material is always very thin and is glued in place. This is more frequently done in veneer than in solid wood, and the thickness of the veneer usually represents the depth to which the pattern is inlaid. The forms of inlay range from simple straight lines of white or black wood about $\frac{1}{16}$ in. wide, round the edges of surfaces, to representations of flowers and scenery. Figure **16** is an example of stringing and banding round the margin of a surface. The term inlay includes all inlaid work, but different names are given to different classes of inlay. Work of complicated outline, such as representations of natural scenes and highly ornamental patterns, is known as *marquetry*. Geometric patterns are called *parquetry*, and this term is now applied chiefly to floors laid with hardwood blocks arranged in any geometric pattern. *Intarsia* is a very simple kind of marquetry in which pictorial effect is obtained by a few pieces of inlay, the grain and outline of which represents a land or sea-scape without detail. Buhl work, as already noted, is inlay of other material than wood.

Methods of Inlaying. Inlaying of the more complex character is not done by cabinet-makers, but panels or other parts are purchased already inlaid, or inlaid veneer is purchased and either laid on large enough to cover the surface it is required for, or the inlay is contained in a small piece of veneer cut to oval, circular, or other shape, and let into the body of the other veneer. Patterns of plain outline are also sold separately. Built up patterns and inlaid veneers when purchased in this way have their parts united by being stuck on a backing of paper. This is the usual method of forming patterns even when done by the person

1. Toothing plane-iron **2.** Veneer on heart side of wood **3** and **4.** Veneering hammer **5.** Two pieces of wood veneered with caul between **6.** Veneering presses **7.** Edge view of a scraper **8** and **9.** How to use a scraper **10.** Scraper in a handle **11.** Smoothing the edge of a scraper **12.** Removing the burr **13** and **14.** Sharpening **15.** Preparing for re-sharpening **16.** Inlaid banding **17.** Example of dowelled joint **18.** Dowel centres marked by pins **19.** Centre pop **20.** Punching a nail **21.** Withdrawing a nail **22.** Countersinking with a gouge **23** and **24.** Using saw and plane in inverted position **25.** A panelled top **26.** A top with softwood core **27.** Example of a carcase. **28.** Methods of fitting shelf ends **29.** Shelf end with stopped rebate **30.** Method of cutting grooves for shelves **31.** Case or pedestal with drawer runners **32.** Fitting of runners **33.** Another method of fitting runners

who afterwards intends to inlay them in another surface. The paper is intended to be on the outer side when the pattern is inlaid, so that it can be cleaned off when the glue is set. If turned the other way the paper would prevent the glue from holding the inlay properly, for paper can easily be split if glued between two pieces of wood.

Fitting Inlay into Veneer. There are two methods of fitting the parts of patterns together and fitting inlay into veneer. One is to cramp or stick temporarily the pieces face to face, and cut through both with a fine saw or sharp knife to the outline required, thus obtaining an interior part which will fit into a corresponding exterior one. The other is to cut a pattern out separately, and lay it on the surface in which it has to be sunk, and mark its outline with a sharp pointed knife or scriber, and cut out to these lines. For inlaying into solid wood, this latter is, of course, the only method. Incision is made to the required depth by chisels, gouges, or a knife with a sharp point, and the recess for the inlay routed to the required depth, with a small *router* if in solid wood, or with a chisel when only veneer has to be removed. A router is a plane which can be set to cut a channel or recess to uniform depth. It will be illustrated farther on. But most of the inlaying the cabinet-maker is required to do is the insertion of plain parallel strings, the channels for which can be cut very rapidly with a double-toothed cutting gauge, similar to a mortise gauge, except that the cutters are deep and thin, to penetrate well into the surface. This gauge is set to the width of the inlay, and makes two parallel cuts in the surface at the required distance apart. The material between these can be removed at a stroke with a router. The inlay is glued in, and pressure put on it till the glue is set. The inlay may be parallel strips cut from veneer, or more frequently it is bought ready cut into strips known as *strings* or *stringing*. Mosaic bandings are also often employed. These are made up in innumerable patterns of different woods arranged in different ways. They are made by gluing up the patterns in lengths and then slicing off in strips about $\frac{1}{16}$ in. thick or less. The grain must run plankwise with the surface when the inlay is glued in place. Inlay designs are nearly always made in quantity either by gluing up a thick pattern and slicing off, or by sawing out a number of thicknesses together. In either case it is not regarded as cabinet-makers' work.

Other Methods of Ornamentation. Next to mouldings, which have been treated of in Joinery, carving is the most important of all decorative methods. Carved portions of work come into the cabinet-maker's hands already finished by the carver, and he is concerned only with fixing the parts in place or fitting them together. The same is true of turned work, which is done by wood-turners. This is generally not intended chiefly as ornament, but it is so easy to make turned work ornamental that it is done even in the simplest and cheapest work, almost the only exception perhaps being the use of plain parallel rods in some chairs and other articles. These, however, are not turned in the ordinary sense, but made cylindrical by being passed through a machine with revolving cutters. Another form of ornament on furniture is known as *ormolu*. This consists of metal ornaments with gold plated or gilded surface, attached to the wood by brass pins or fine screws. *Fretwork* occupies a position of some importance in light fancy articles of furniture. In this very fine saws are used to cut ornamental patterns in thin wood. The lines to cut to are transferred from patterns on paper. Fretwork for the cabinet-maker is cut by machine saws and comes into his hands ready to be attached to the work. *Pyrography*, or *poker* work is a rough means of ornamenting a surface by tracing a pattern on it with a red-hot platinum point, which burns the required outline, making a slight channel in the surface of the wood, and showing as brown or black lines according to the degree to which it is burnt.

Furniture Construction. The method of constructing a given article may vary with circumstances. If the work has to be done as cheaply as possible without much regard for quality, the parts are prepared and put together in the simplest style, glue and nails being the chief means of union. If the best work is required the best forms of joints are adopted everywhere instead of the parts being allowed to depend solely on the medium which holds them together. The quality and amount of material used may also vary. Soft wood is cheaper than hard, does not look so well, and is less durable. Pieces of wood, alike in kind, vary in quality and strength. Thin material may be used for economy when thicker would be more suitable, or the strength of an article may be diminished by economising material in hidden parts. There are, of course, some exceptions where cheapest and best work must be done alike, because there is no other practicable way. The arrangement of the parts of an article of furniture has to be made with a view to exterior appearance, economy of material and labour, and sufficient strength to serve the intended purpose.

Dowels are employed more in cabinet work than in joinery. They are used very often instead of tenoned joints. Figure **17** is an example. In many cases it is troublesome to get the centres of the holes for them marked correctly by measurement or by gauging from an edge, and then other methods may be adopted. One very convenient way is to locate them by means of pin marks, as in **18**. Ordinary pins are placed in the joint, and pressure applied so that the pin heads leave imprints on both parts, which serve as centres on which to bore the dowel holes. Another method is to have a number of centre pops [**19**]. These might be made of wood with a steel point inserted, but are better turned in solid metal. The body is the same diameter as the dowel, and is intended to be inserted in the dowel hole, which has first been bored in one of the pieces to be dowelled. The thin flange shown at the top prevents if from going farther in. The other piece of wood is then adjusted in position, and a tap with a mallet, or a little pressure, causes the point in the centre to leave an impression corresponding exactly with the centre of the hole required in the other piece. Another method is to cut a piece of paper to the shape of the jointed surface and prick holes through at the places where dowels are required. The paper can then be laid in position on each surface, and the centres marked through the holes in the paper. Another way seldom practicable in cabinet work is to cramp the pieces of wood together and bore entirely through one piece into the other.

Insertion of Screws and Nails. Screw and nail heads are seldom allowed to show on exterior surfaces. Where possible they are put in from behind as described in joinery. Screws with rounded heads are preferred when the heads cannot be concealed. In some cases screws with flat heads are provided with metal cups which give a neater appearance. Nails are punched below the surface with a hammer and punch [**20**], and the holes filled flush with wax stopping coloured to

suit the wood or stain. Figure 21 shows a method of withdrawing a nail without injuring the surface of the wood. The blade of a square or other sheet metal is laid on the surface to receive the leverage of the pincers, and so prevent the wood from being bruised. Figure 22 shows how screw holes may be countersunk by scooping out with a gouge. This is not quite so neat a method as with a countersink bit, but is more expeditious, and is frequently adopted. Needle points are used for attaching light mouldings and other parts. They are similar to ordinary needles, but without eyes. They are driven in the required distance, and then snapped off flush with the surface, and, of course, are then almost invisible.

End grain appearing flush with a surface plank way of the grain is objectionable, and therefore tenons are seldom carried through unless at the back of an article where they will not be noticeable. Even under veneer through tenons are objectionable, because a slight amount of shrinkage causes them to bulge the veneer. In other cases end grain is generally allowed, if possible, to project beyond to avoid a flush joint. Except when they are glued, flush joints are always objectionable, even when the grain of each part corresponds, and consequently they are usually beaded, or moulding is attached to conceal them. The shooting board is used a great deal by cabinet-makers. Small pieces of wood are often sawn, and planed with the tools in an inverted position as in 23 and 24, the saw or plane remaining stationary and the wood being worked backwards and forwards.

Construction of Table Tops. The tops of tables, counters, sideboards, bureaus, etc., are frequently thickened or lined up at the edges, as described in Joinery; but there are several methods of building up the main surface. The simplest way is not to build up at all, but take solid board of the required length and width, and keep it flat by its attachment to the framework of the article, while at the same time allowing it freedom to shrink or swell without splitting. If very wide, this is usually done by buttoning. Comparatively narrow widths may be screwed or nailed with safety, but glue should never be used except in cases where the grain of the parts it is attached to is arranged in the same direction so that all these parts, if well seasoned, when put together can be relied on to shrink or swell similarly. Another method of keeping a top flat is to dowel or tongue flush cleats to the ends, generally with mitred corners. This is satisfactory if the wood is well seasoned, and the width not very great. A better way is to frame and panel the top with a flush panel as in 25. Here also the corners are better mitred, and the joints strengthened either by tenons or dowels. Another method is to half-lap the joint and mitre the upper face only.

The tops of writing-tables panelled as in 25 generally have the panel slightly below the surface of the frame, so that leather or cloth can be glued on the panel to make a flush surface. When solid tops are covered with leather, the border round the leather is veneer glued on. Veneered tops should have their edges corresponding in appearance with the veneer, so that it looks like solid wood, and as edges are generally moulded, and therefore difficult to veneer, the top is built up as in 26. A core of pine or cheap mahogany has an edging of more costly wood, corresponding with the veneer, glued round it, end grain pieces frequently being put on the ends. Both the upper and under faces of the core are generally veneered, so that the core is entirely enclosed. In such cases it is very often cross veneered, as in 26. Another method is to frame as in 25, making the frame of, say, mahogany or walnut, with a pine panel, and to cover this with veneer to match the frame, the veneer generally standing its own thickness above the surface of the frame, as in 26. Another way is to put a hardwood edging with mitred corners round a pine frame and conceal the latter by covering with veneer or leather.

Carcases. Carcases may be either panelled or plain boarded. Sometimes a skeleton framework of posts and rails is built to attach the panels or boards to, and sometimes there is no such frame, but the parts are fitted together at the corners in box fashion, either dovetailed, tongued, and grooved, or, in some cases merely nailed or screwed or secured by glue blocks. The method depends to a large extent on the character of the article. In cabinet work, parts are sometimes panelled mainly for appearance. Carcases intended to stand on the floor, without legs, usually have a few inches of plinth below the baseboard of the carcase. In heavy articles of furniture this plinth is sometimes separate, the carcase merely resting on it; but in most cases the sides of the carcase either extend below the baseboard, and the plinth is screwed against them, or the plinth is partly against and partly beneath, and secured by glue blocks or screws or nails.

A simple example of a carcase is shown in the bookcase [27], the frame of which, with plinth and cornice removed, would consist of two plain uprights with shelves fitted between. The uprights should, to make the most substantial job, continue to the floor, and the plinths be nailed or screwed against them from the inside, the plinths being simply an increase in the thickness of material at the sides. The plinth along the front would have the edges of uprights and bottom shelf to bear against, and would be secured by glue blocks in the interior angles. A plinth at the back would be treated similarly, but generally plinths and cornices are carried only round front and sides, leaving the back a plain flush surface. The cornice is built up by first covering the top ends of the uprights with a plain board, overlapping an inch or so at ends and front, and then fitting moulding beneath this attached in the same way as the plinths, by nailing the end pieces and blocking the front. The objection to gluing the ends is that the grain crosses. So far the constructive details have been illustrated in Joinery, but an important matter to be considered now is the attachment of shelves to uprights.

Methods of Fitting Shelves. There are a number of ways of fitting shelves, and, as a rule, in cabinet work they must be fitted securely without exterior sign of how it is done—that is, without nails in the ends, on cleats beneath, or rebates showing at the front. Shelves for books are often made adjustable, but at present we are considering fixed shelves of all kinds, including bearers and runners for drawers. In an article with plain shelves fitted to plain sides, as in 27, the shelf ends would be rebated into the sides by one of the methods shown in 28, A, B, C. The grooves in the sides, however, are stopped about ½ in. short of the front, as in 29, and the shelf ends notched to correspond. The shelves are inserted from the back. A plain rebate or housing, as at A in 28, affords satisfactory support for the shelf, and is more easily made than the dovetailed grooves at B and C; but the advantages of the latter are that they tie the sides and keep them tightly up to the shelf ends. Ordinarily, however, the plain housing, as at A, is used, and the sides are secured at top and bottom; 30 shows how these housings are cut. At the right-hand end of 30, a tenon saw is being

used to cut the depth, an inch or so at the front having previously been cleared out with a chisel to allow the saw to work. At the left of **30** a router is being used to cut the groove to a uniform depth. Generally, a chisel would be used first to clear most of the material out. A rebate plane might be employed in a long groove, instead of a router, but the fore part, which could not be touched by the plane iron, would have to be finished with a chisel.

The top of the bookcase in **27** would in most cases be nailed on, and the bottom shelf might be nailed as the plinth would afterwards cover the nail heads, but this could be avoided by the use of glue blocks beneath, and generally the ends of this shelf would fit in veed grooves and be glued.

Methods of Fitting Drawer Runners. Figure **31** represents a case or pedestal with runners and bearers to receive drawers. This is an example of sides tied at top and bottom, and requiring only plain grooves for the runners. At the bottom a complete frame stub-tenoned together is screwed or nailed into rebates, which may run right through to the front, as the front edge, and also the screw heads at the sides, are afterwards concealed by a plinth. At the top, *stretchers* are dovetailed in. The intermediate runners are then not required to play any part in tying the sides, but are slipped into plain rebates. Details are shown in **32** of a grooved side, and a runner with its tenon to fit into the bearer in front. The inner edges of runner and bearer are shown grooved, as would be the case if a panel or dustboard was to be inserted between drawers. Figure **33** shows another method in which the side of the article is not grooved for runners, but recesses are cut instead to receive the ends of the bearers at the front and the back ends of the runners at the back. In a few cases bearers are tenoned completely through sides, but, as a rule, a shallow recess only is cut. A rail or bearer connecting the back ends of a pair of runners is not necessary unless to serve as a tie to the sides, or stiffen a back. Runners are often made of oak or other hard wood, which will not get worn very readily by the drawers sliding on it.

Attachment of Backs and Tops. Backs are tongued into a groove as in **34**, or fit into a rebate, as in **35**, or in rough work are simply nailed on the surface. A back may be simply a plain, thin piece of wood, or it may be framed and panelled, or a middle course is to make it as in **36**. In **36, A**, it fits in grooves at the sides, but is not enclosed by top and bottom rails as panels would be. The muntin in the middle is screwed or nailed to top and bottom of the carcase, but the boards in the grooves may be left free to contract or expand. Figure **36, B**, is a modification of this, and is very commonly adopted. Instead of the edges of the thin boards fitting into grooves as at A, they are kept in position by one or more rebated bars, as shown at B. The thin pieces, as well as the bars, are generally nailed to the carcase.

Tops may be simply nailed on, or dovetailed in, or screwed from beneath, or fitted on to a dovetailed tongue, which may be nailed on the ends, as in **37**. In all these cases, when the grain of top and sides coincide, glue blocks may be used also, if there is no objection to their presence. In most cases tops lap over, as in **37**, but when the ends have to be flush, the best way is to dovetail them in with lap dovetails, which do not show on the sides. When tops are screwed on, the screws are usually put from beneath through stretchers, which themselves are lap dovetailed in, as in **31**.

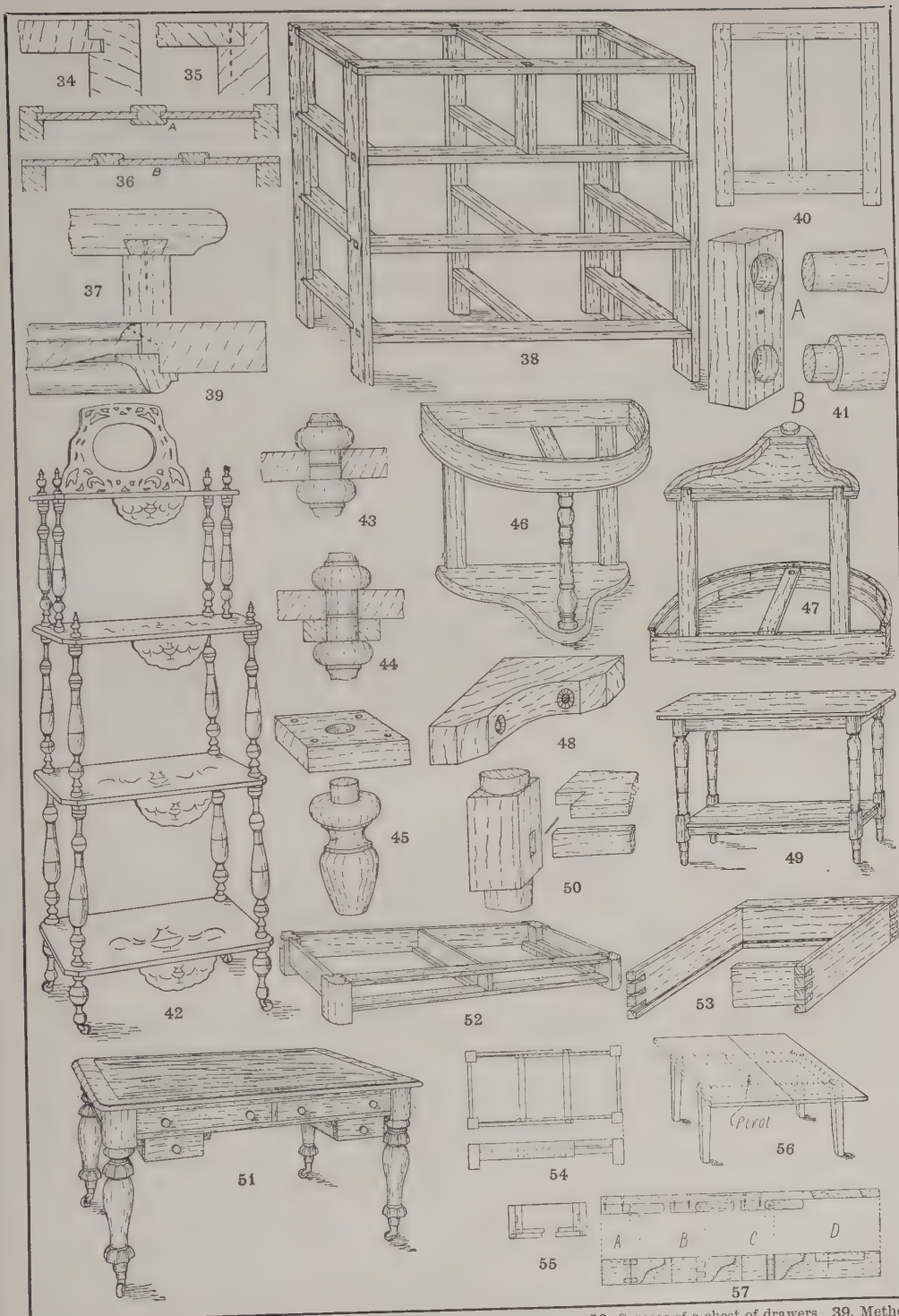
In **38** we have an example of carcase work first framed and afterwards covered as required, the boarding being attached by screws put through from the inside. It represents the skeleton carcase for a chest of drawers. All the material in the framework is, say, 1 in. thick. The boarding at the ends would be, perhaps, $\frac{3}{4}$ in.; the back $\frac{1}{2}$ in., or less, and the top 1 in. As the sides of the frame are to be covered, there is no objection to carrying the tenons through the uprights, and screwing the side and back uprights together as shown. The runners are tenoned at front and back, and notched into the side uprights. The ends of the longitudinal rails at the top are dovetailed to the tops of the uprights. The uprights at the front are, say, 4 in. wide, and all the other parts 3 in. This framework is, of course, equally suitable for attaching panelled sides and back to.

As an alternative to grooving, panels in cabinet work are sometimes inserted as in **39**, a rebate being planed or a bolection moulding glued on the front, and a fillet bradded round the back to keep the panel in.

Figure **40** is a face view of a frame for a panelled side or end showing how the bottom rail is kept above the floor. The lower part is afterwards covered by the plinth, which laps about an inch above the lower edge of the rail. The joints are either all stub-tenons, or, as there is no objection to it, the back tenons are sometimes continued through, as shown.

Framed Work. This consists of rails and posts, or legs, not boxed in, chairs being the commonest example. The parts are united by dowels or tenons, or small members have their ends housed into larger ones, or, in the case of cylindrical parts, the end of a member may be reduced in diameter. Examples of these are shown at A and B in **41**. These are usually held by glue alone, but occasionally fox wedges are inserted. But if the parts fit tightly and are well glued there is little risk of their ever coming apart. An article like **42** is built up by gluing the ends of the columns into holes in the shelves, as in **43**. If the shelves are very thin pieces may be glued to the under-surface as in **44**, to increase the depth of the stud holes, the pieces glued on appearing as part of the column. If it is desired to stiffen the shelves to prevent warping, battens may be screwed across in place of separate blocks, and the stud holes may be bored through these. The stumps of drawers are fitted into blocks, as in **44**. In some cases they are screwed in. Wood drawer knobs are generally screwed into the drawer fronts.

Figure **46** is an example of framed work in which some amount of building up is involved to obtain the required curves. It is the frame of a semicircular washstand intended to be covered with a marble top. The details of its construction are shown in **47**, in which it is turned upside down. The semicircular top on which the marble rests is formed by gluing two layers of segments which are afterwards worked to the sweep on the outside and veneered, the inside being left as it leaves the bandsaw. A bead is formed on the lower edge by nailing on a thin layer of segments with outer edge rounded and projecting. The ends of the sweep are connected by a straight rail notched in flush, and forming the back of the table part. A transverse bar extends from the middle of this to the sweep, being notched flush into the under edge of the latter and covered by the bead segments, and nailed on to the edge of the back rail, the depth of the rail being less than that of the sweep. The main purpose of this transverse bar is to provide an attachment for the top of the pillar, which comes within the curved front. The base is a piece of $\frac{1}{2}$-in. wood lined up to about 2 in., and



34—36. Methods of inserting backs **37.** Top secured by dovetailed tongue **38.** Carcase of a chest of drawers **39.** Method of inserting panels **40.** Frame for a panelled end **41.** Methods of fitting cylindrical ends **42—44.** An article of simple construction with details **45.** Fitting of drawer stump **46** and **47.** Example of framed work **48.** Rough wood bracket **49** and **50.** Small table with detail **51.** Writing table **52.** Frame of table **53.** Method of constructing drawers **54.** Frame of extension table **55.** End view of rails **56.** Table with folding and pivoted top **57.** Methods of hinging brackets for flap tables

veneered. It does not rest directly on the floor, but on projections extending about an inch below the thickening or lining pieces. The two back uprights are carried through, as shown, to form feet at the back, and one other is formed at the front by a pad, which is nailed on. The pillar is slipped in after the parts are together, and nailed from above and below.

Brackets, either of metal or wood, are often used to strengthen joints. A wood bracket is shown in **48**. These are roughly sawn, but the angle of the back must be accurately finished. They are used only in hidden parts, a common instance being the interior angles of chair seats. Where brackets are required in exposed places they must be neatly finished, generally to a more or less fanciful shape, and if of wood, the screws are inserted through the work into the bracket instead of through the bracket, as in **48**.

Chairs. The seats of these, when not of solid wood or turned rings, are usually dowelled or tenoned, and glued, and sometimes strengthened by brackets of wood or metal screwed into the interior angles. The back and back legs are in most cases continuous, and the seat notched into them and screwed or nailed. The front legs are glued into bored holes. Rails connecting the legs are glued in similarly. Cross-pieces in the back are tenoned, or dowelled, and glued. Very often some of the parts are of bent wood. Special appliances are employed for making these. It is done by steaming the wood and clamping it in an iron mould, the mould itself often being formed with a chamber and pipe for steam heating its surfaces.

Tables. The methods of framing the legs and rails and buttoning on the tops of plain tables has been described in Joinery. Small tables, such as **49**, do not require such elaborate methods. The top would not be buttoned but screwed on through the rails, or if very narrow, glue blocks might be used. The rails might be housed or tenoned into the legs, but in most cases would be dowelled. The bottom rails, to which the tray or shelf is attached, might be housed into the legs, as in **50**, and the tray notched to fit the legs. The rails then would be glued in and nailed through the inner faces of the legs, where the nails would not show, though in many similar cases there is no objection to putting fine nails through from the outside if required. In some cases the tray might be attached to the under edges of the rails instead of on top, and then would be nailed to them. Figure **51** is a heavy writing-table, which does not differ greatly in constructive details from plain tables described in Joinery. Its frame is arranged to receive two drawers in the side instead of one in the end. Its top is built as in **26**, but covered with leather bordered by veneer. Its turned legs, with castors, are a detail which does not affect the construction of the table. A general view of the frame with top removed is shown in **52**. The lower bearer is tenoned into the legs while the upper one and the end and back rails are dovetailed into them. Drawers are constructed as in **53**. In cheap work the backs are nailed instead of dovetailed.

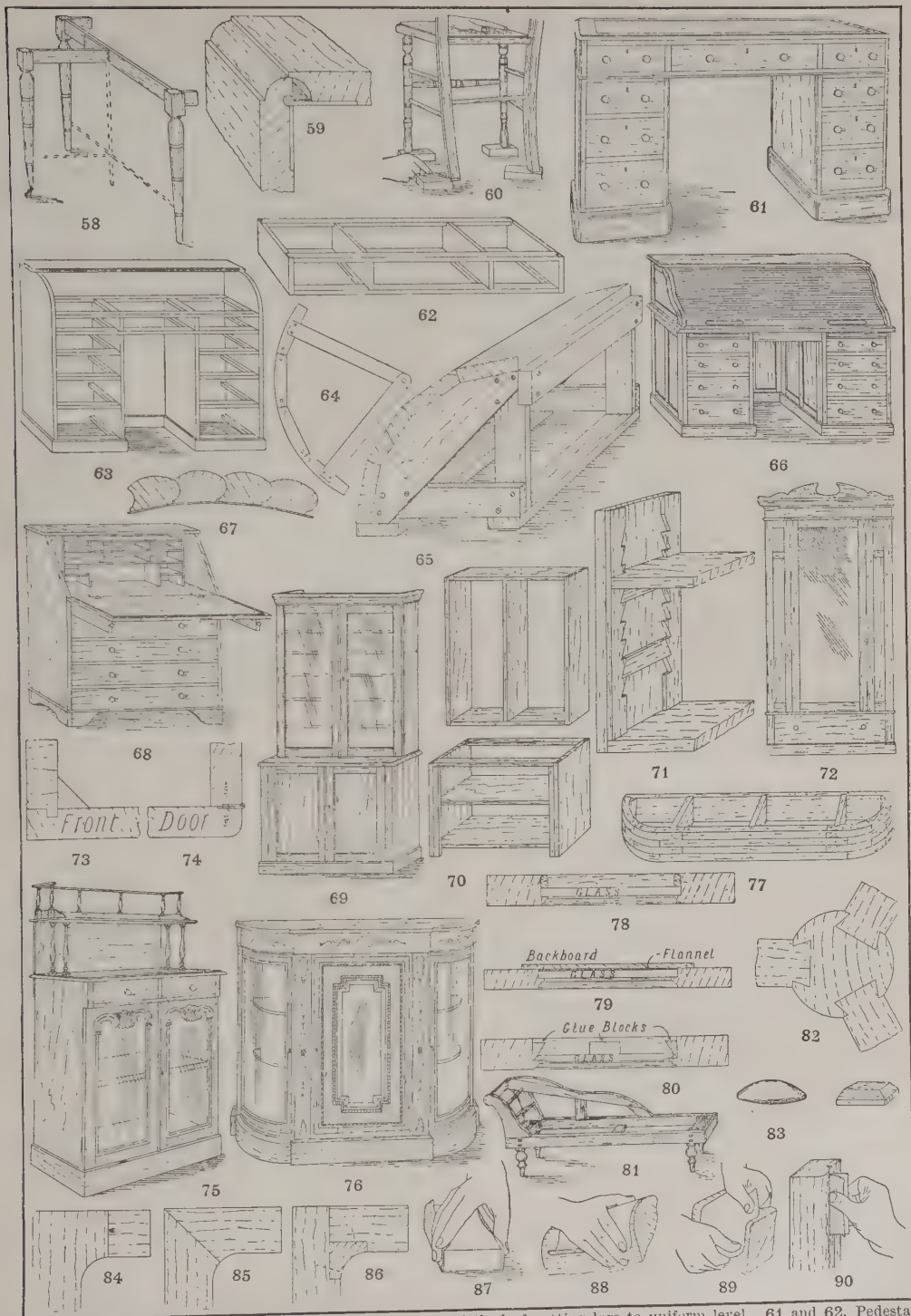
Extension Tables. The commonest form of extending table is shown in **54**. In this there are double rails secured to the legs at opposite ends, and, when closed, the free ends of each pair of rails fit loosely into housings in the legs. They are also tied laterally by stretchers. The rails are kept in alignment by tongues and grooves, usually dovetailed, as in **55**. Large tables of this class have three sets of rails, the middle ones being supported by the others or by extra legs. The frame is usually extended and closed by a screw worked by a key, and a separate leaf fills the space left when the ordinary top is opened. Another form of table with a folding top is shown in **56**. In this the top is pivoted, so that when unfolded it can be swung round at right angles to its position when closed, the long way of the frame then affording sufficient support for both flaps. When square legs of tables or other articles are tapered, as in this example, all the taper is cut from the inner faces.

Flap Tables. Ordinary flap tables have their flaps supported by brackets, swinging legs, or slides which draw out from the frame. Figure **57** shows methods of attaching brackets to the rail of a frame. The simplest is to hinge them, as at A, but for appearance the joints at B and C are preferred, C being considered the neatest; B is known as a finger joint, and C as a knuckle joint. Another way is to pivot a piece in the top of the rail, as at D, which can be swung out to support the flap. The point in favour of this is that it lies flush with the rail when closed. Swinging legs are hinged, as in **58**, sometimes with a tie near the bottom as dotted. The rule joint [**59**] is the usual method of hinging flaps.

Articles with more than three legs sometimes require levelling to prevent them from rocking, due generally to inaccuracy in the superstructure. The exact amount to cut off may be marked as in **60**, by standing the article with three of its legs on blocks of equal thickness on a true surface, and setting a fourth block against the fourth leg, which should be the one which requires cutting. The top surface of this block represents the correct length to cut the leg to. Another way is to mark from the floor with dividers instead of getting the depth from a fourth block.

Writing-tables and Desks. These are generally of the pedestal type, with a kneehole between. A table in which the top and pedestals are in separate parts is shown in **61**. The construction of a pedestal has already been illustrated in **31**; **62** shows how the top is framed. The grain of the ends runs horizontally, but in this example the table is veneered and the grain of the veneer on the upper part is made to correspond with that of the pedestals.

More frequently pedestal tables are made in one framework. Figure **63** is the carcase of a cylinder fall-desk. The sides are shown plain, but in many cases would be panelled. The table generally fits in grooves in the ends and is made to draw out several inches beyond the front. Figure **64** is an end view of the fall. It is pivoted at the centre from which its curve is struck, the connecting pieces generally being of hoop-iron. It is staved up on a block as in **65**, and the staves should be dowelled or tongued as well as glued. The back of table and back of fall are usually connected, so that the fall opens when the table is drawn out and closes when it is pushed in. Figure **66** is another form of roll-top desk with a flexible fall. This is an improvement on the cylinder fall, and is now in more common use. In this the fall slides in grooves in the ends. It is formed by gluing strips of wood on canvas, as in **67**. The pedestals are panelled and connected by a panelled back and by a stretcher in front secured by metal angle brackets. The drawers lock automatically by means of catches which clip their backs. These catches are released by pressure of the fall when it is pushed back as far as it will go. The lock on the fall is of a kind which locks itself when the fall is drawn down, and requires a key only for unlocking. These desks are usually made of oak. The table is solid board screwed directly on the pedestals. A writing bureau is



58. Method of fitting swinging legs **59.** Rule joint **60.** Method of cutting legs to uniform level **61** and **62.** Pedestal desk and detail of top **63.** Carcase of cylinder fall desk **64.** End view of cylinder fall **65.** Cylinder fall built up on a block **66.** Desk with flexible or tambour fall **67.** Section through fall **68.** Writing bureau **69** and **70.** Bookcase and details of carcase **71.** Saw-tooth arrangement for adjusting height of shelves **72.** Wardrobe **73** and **74.** Methods of jointing front and hinging doors **75** and **76.** Cabinets **77.** Method of building up base and top with curved ends **78—80.** Methods of fitting glass in furniture **81.** Frame of a couch **82.** Joints of legs in a central post **83.** Buttons **84—86.** Methods of rounding interior angles **87—90.** Methods of glass-papering

shown in 68. The cover is hinged, and when opened is supported by two slides which draw out from the carcase. On writing-tables with level tops loose desk slopes are often used. These are very simple in construction, sometimes consisting only of a piece of board tilted by two tapered battens screwed to its under surface.

Bookcases. Sometimes these consist merely of an open carcase with shelves, but to keep dust from the books the best cases are fitted with glass doors. A common type of bookcase is shown in 69. In this the upper doors are glazed and the lower ones wood panelled, as there would be some risk of glass getting broken in the latter. The parts are made separate, as in 70, and the lower part is wide enough to project 4 in. or 5 in. in front of the upper, thus providing a useful ledge and being better proportioned for the larger books it is intended to contain. The upper part should have a vertical partition in the middle behind the meeting stiles of the doors. If the length of the shelves exceeds 4 ft. the lower part would be better with a similar partition. The upper part is lap dovetailed at the corners, and the partition housed in and screwed. The lower part has two stretchers lap dovetailed in at the top, and its bottom may be housed and nailed if covered by plinth, or fitted into a dovetail groove and glued, and in either case may be further strengthened by glue blocks in the angle beneath. The front edges of the sides may have pieces glued on to form pilasters, thus giving the sides an appearance of greater thickness than is actually the case. A top is screwed on to the stretchers of the lower part, and the upper part is screwed on to this. The doors of the upper part are hinged on the face of the frame.

Shelves are generally made adjustable in height. A common method of doing this is to screw saw-toothed strips about $\frac{3}{8}$ in. thick against the sides, as in 71. Bearers of similar thickness are made to fit between, and on these the shelf ends rest, the ends being notched at each corner to clear the saw-tooth strips. The alternative to this method is to have two columns of holes corresponding with the saw-teeth in the last example, and to insert pins in these to support the shelves. These pins are of metal, and there are several varieties of them.

Sectional bookcases have become very popular and are best where the number of books is constantly increasing. Bookcases like 69 look well as an article of furniture, but they are suitable only for a fixed quantity of books. Sectional cases consist of a number of separate boxes each with a capacity, say, for twenty average books. These sections are all alike and provided with simple means of uniting them end to end or one on top of another. A glass door may be fitted to the front of each section. A convenient arrangement is to hinge the doors at the top, and make them so that when lifted into the horizontal position they can be slid back into the case, leaving the front clear and the books uncovered.

Wardrobes and Cabinets. Wardrobes are a common example of large carcase work. They are usually made in three parts, the plinth and cornice being separate from the body, and these parts fitting together loosely with blocks or dowels as guides, and in some instances screwed together. Figure 72 is an illustration of an ordinary plain wardrobe. It has a drawer at the bottom, and the door in the middle is panelled with a mirror. The sides are lap dovetailed to the top and bottom similarly to the bookcase in 70. In the best work, backs are panelled, but generally matchboarding, ply board, or a number of panels between muntins, as in 36, are put in the back. As the doors of wardrobes do not extend across the entire front, pieces, either panelled or plain, must be put on. In many cases these are nailed or screwed directly on and the holes plugged. Where this is objectionable they are glued and dowe led, or screwed from the inside, and sometimes glue-blocked. Figure 73 shows a joint between front and side. With a drawer at the bottom, as in 72, the parts of a large wardrobe would generally be jointed at the bead above the drawer, and the plinth would generally be solid with the lower part, as in the bookcase [69]. The methods of constructing more complex wardrobes do not differ much from what has already been described. Doors, whether in the middle or at the sides, close against the front edges of the frame, as in 74, which is an example of a door hinged to a side. Drawers in the lower part generally work between pilasters formed as in 70, guides of course being required flush with the pilasters, and the width of the latter representing a corresponding reduction in drawer width, the space behind the pilasters not being utilised. Beads are often formed as in 73, where joints occur on the outer faces of front and sides.

Figure 75 is a cabinet with glass doors, and drawers and table above. Its carcase is framed with bottom, shelf, bearer and runners for drawers, and stretchers dovetailed in at top to screw the table on to, none of which differs essentially from what has already been described. The back portion, which forms the main support of the upper shelf, is panelled and screwed on behind. Figure 76 is another form of cabinet, veneered, inlaid, and decorated with ormolu. It has three doors, the middle one containing a mirror, and the two side ones being curved, with glass panels. The curved rails of these doors might be of solid wood worked to the sweep and veneered, but the best way is to form them of a number of layers of veneer bent round a block and glued together. The base and top may be built up as in 77, and the four uprights which enclose the doors may be halved in flush with the outside faces, and the outstanding blocks put on after.

Glass in Furniture. The ordinary methods of inserting glass are shown in 78 to 80. In 78 the glass drops into rebates and is secured by wood fillets behind. The method shown in 79 is suitable only for mirrors. In this the glass goes into a rebate as before, but is protected behind by a backing of flannel and board, the flannel being flush with the back of the frame, and the board screwed on. In 80 the glass fits loosely in the rebate, and is centred and secured by glue blocks as shown. Glass divided by ornamental bars into a number of panes is fitted similarly to that in ordinary windows, except that wood fillets are more generally used than putty. When these have to be bent to curves they are generally of birch or other flexible wood. Where the bars form a very ornamental pattern they are sometimes merely stuck on the surface of a single sheet of glass. Plain and bevelled mirrors may be purchased in great variety of size and shape, or can be obtained to order.

Miscellaneous. Figure 81 is the frame of a couch. The feet are supposed to be dowelled to the under part of the frame. An alternative is to tenon the rails in similarly to those of a table. The upper parts which form the back and end are tenoned or dowelled and glued in the most convenient way to produce the outline desired. Figure 82 shows the

usual method of fitting the feet of circular tables and other articles into the centre post. Screw heads are sometimes concealed by gluing buttons [83] over them. Three methods of forming rounding interior angles in frames are shown in **84** to **86**. Figure **84** is satisfactory, but involves either gluing on a piece or cutting out from one of the members. Figure **85** is a good method when the parts are mitred. Figure **86** has the advantage of allowing the straight pieces to be planed up parallel.

Glue blocks, as illustrated in Joinery, are very commonly used in cabinet work. In many instances, where widths are not great, they are used across the grain. The union of rails to table legs, for instance, is often strengthened in this way. Wire nails are very often used on exteriors without any attempt at concealment, while in other cases they are punched in and the holes stopped, but their presence can, of course, be detected if they are looked for. Metal connections, such as brackets and thin plates or strips, screwed on, will often make a substantial job of what would otherwise be weak owing to slender proportions of wood or a difficulty in making a sufficiently strong joint between parts.

All parts of furniture that are either ornamental or standard in form may be purchased ready made at not much higher prices than the cost of the material. Thus, prepared and carved panels, pediments, brackets, trusses, plain and embossed mouldings and beadings and pressed wood ornaments, can be more economically purchased than made. All kinds of turned work, such as legs, spindles and knobs, are kept in stock by turners and seldom require making to order. There are also so many designs in inlay available that the cabinet-maker never needs to do anything more than select from them. All these articles may be purchased either from specialists or from large firms that stock all of it.

Glass-papering. On a large scale this, and scraping also, are done by machines. Glasspaper is used first to remove tool marks and other slight inequalities and secondly to make surfaces smooth. It is necessary to rub down with glasspaper after the first coats of varnish or stain have dried, to remove the roughness caused by the raised grain. Surfaces, therefore, have to be glasspapered two or three times in the course of finishing the work, and each time paper of finer grade, or paper that has been worn finer by use, is required. A flat surface is done with the glasspaper, kept flat on a rubber as in **87**, and the direction of the rubbing must be with the grain or the surface will appear scratched. Cork rubbers are best, but often a block of wood is used instead. Rounding surfaces are done with the hand, as in **88** and **89**. Hollows are generally managed similarly, though in some cases rubbers of the correct shape are made. Quirks and narrow places may be rubbed with paper simply folded, as in **90**, or wrapped on a thin piece of wood or metal.

Staining. This is done to improve the colour of soft and cheap woods and make them resemble more expensive varieties. The resemblance, however, is chiefly in colour, for in most cases the grain shows unmistakably what the wood actually is. In staining, any inequalities in the shade of the natural wood are corrected. Some parts are generally lighter or darker than others, and this looks especially bad when two pieces are glued together, and the joint is made conspicuous by a sudden change of colour. This, of course, is avoided as far as possible in selecting the wood, but it is further corrected by applying an extra quantity of stain to light parts to make the colour uniform. This matching of the colour of parts is done more or less in nearly all polished work, even when the natural colour of the wood is supposed to be showing. Stains are sold in liquid form ready for use, and are applied with a brush. Hard woods may sometimes be improved in appearance by having their natural colour darkened. Wood darkens with age, but is done artificially by oiling, by staining, or, in the case of oak, by fumigating with ammonia.

Polishing. This is the usual method of finishing cabinet work. There are several ways of doing it, but by far the commonest is known as French polishing. In this the polish is simply shellac varnish (which is shellac dissolved in methylated spirit) applied with a rubber instead of a brush. In order that the polish may be permanent it is necessary to ensure its not becoming absorbed into the wood surface and losing its lustre. The pores of the wood, therefore, are filled by rubbing in a filling medium to economise time and material in applying the polish. There are many fillers employed, plaster of Paris and whiting being common ones, made into very thin paste with oil, water, or turpentine. The filler should be coloured to suit the wood. After this has dried and been rubbed down the process of *bodying in* begins.

The rubber with which polishing is done is a pad of cotton-wool damped with polish and wrapped in a piece of soft linen rag, one thickness of linen only covering the wool. The polish is rubbed evenly and quickly with light pressure of the rubber over all parts of the surface to be polished. The movements of the rubber are unimportant as long as all parts are treated equally. As the rubbing proceeds, the polish dries and the pressure then may be slightly increased. A little linseed oil is applied to the linen when it does not move freely over the surface, but too much oil will make it impossible to get a good polish. This bodying in should properly be done three or four times, with intervals of several days between each, otherwise it is likely to sink in and diminish the lustre of the polish. The coat of polish should be as thin as possible, to show up the figure of the wood and avoid the yellow colour of a thick coat of shellac. The bodying in is followed by a concluding process called *spiriting off*. In this a very thin polish and finally methylated spirit alone is used to remove oil, smears, rubber marks, and any inequalities. It is, in fact, polishing the surface of the coat of shellac, and, if carried too far, will dissolve and remove the shellac and so spoil the work. The final rubbing should follow the grain of the wood. The pressure should be light and the rubber kept moving. Intricate parts are difficult to polish, and are generally given four or five coats of thin varnish with a brush.

The mediums used in other kinds of polishing are chiefly wax and oil. They give comparatively dull results and are used only for special purposes.

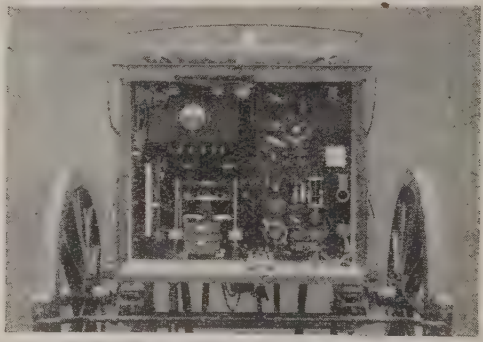
W. J. HORNER

CABINET-MAKING CONCLUDED—END OF GROUP 14

WIRELESS MECHANISM AND ITS USES

THE ENGINE AND INSTRUMENT CART OF A ONE AND A HALF KILOWATT FIELD CART MARCONI STATION

INTERIOR OF THE ENGINE CART



INTERIOR OF THE INSTRUMENT CART

WIRELESS FITTINGS ON A BREGUET AEROPLANE

SHARMAN PIPE-LOCATOR

CONDENSERS AND JIGGERS OF A 5-K.W. STATION

A WIRELESS TELEPHONE SET

All the photographs on this page, except the Sharman locator, are by courtesy of the Wireless Press

The Production of High Frequency Currents. The Singing Arc. Applications of Wireless. Transmission of Photographs. Atmospherics. The Wireless Operator.

CONTINUOUS WAVES & TELEPHONY

THE transmission of signals by Hertzian waves naturally led to attempts to transmit speech by wireless, but speech had already been transmitted without the use of wires for many years by means of light.

The Principle of Wireless Telephony. Light, it has been already observed, travels at the same speed as wireless signals, namely, 185,000 miles per second; and both light and Hertzian waves are due to electromagnetic oscillations in the ether, one of their chief differences being in wavelength. If a telephone mouthpiece or microphone be attached to the tube conveying gas to a special type of burner, the words spoken into the microphone will cause vibrations in its diaphragm which will influence the gas supply, and the flame of the burner will vary in accordance with the speech, the light of the flame varying proportionately. By concentrating the light of this flame by means of a parabolic reflector, the rays of light will carry several yards, and can be intercepted by another reflector (or lens) and concentrated on a selenium cell. Selenium has the remarkable property of varying in its electrical resistance according to the intensity of the light in which it is placed. Consequently, as the beam of light transmitted from the transmitting apparatus—varying always in accordance with the speech—is collected and concentrated upon the selenium cell, the resistance of the cell varies and regulates the current passing from a local battery through a telephone receiver, and reproduces the original speech.

Damped oscillations, produced by a transformer or induction coil in the manner already described, have only a frequency of some hundreds or a few thousands per second. Speech, on the other hand, is produced by vibrations which may run sometimes into thirty or forty thousand per second; and in order to transmit speech by wireless it is therefore necessary to employ oscillations which have at least as high a frequency.

Production of Continuous Oscillations. Continuous oscillations of a very high frequency are produced in various ways at the present time, chiefly by means of (1) the singing arc, (2) high-frequency alternate-current generators, and (3) particular types of spark apparatus.

In 1900, Mr. Duddell showed how continuous oscillations could be produced by means of special arrangement of arc lamp, condenser, and inductance, which is shown in diagram form in **27**. Here D represents a source of continuous current, such as a dynamo or battery of accumulators; A is the arc lamp, K the capacity, and J the inductance. A high voltage (400 volts upwards) is usually employed, and the inductance must have a low resistance. The number of oscillations produced in this way has been as high as 400,000, while over 130,000 per second have been actually recorded photographically.

The arc lamp, owing to the physical conditions produced by the shunted capacity and inductance, gives rise in reality to a very high number of spark discharges, or their equivalent, and thus to an almost uninterrupted train of waves. There are various ways of making the speech affect these waves, one being shown in **28**. M represents here the microphone, and B a battery. On talking into the microphone, variations in current intensity are produced in the coil, L, acting as the primary of a high-frequency transformer, of which H is the secondary, H being also the inductance coil shunted across the arc. Choking coils, C C, are sometimes used in the leads from the source of direct current to the arc, but are unnecessary if the lamp is fed from a dynamo or accumulators not supplying power elsewhere. The microphone currents have also been used to influence the field magnets of the dynamo supplying current to the arc, and the arc will then repeat words or music spoken or played into the microphone. With an apparatus of this type a musical arc concert was given by Simon in Frankfurt some years ago.

The Poulsen Arc. Poulsen made a considerable advance in the production of high-frequency oscillations by discovering that practically undamped waves could be obtained if the arc flame were formed between a carbon and a cooled metal electrode (or pencil) in an atmosphere of coal-gas or hydrogen The shunt circuit need then have only a very small capacity. A further feature of the Poulsen arc is that two magnets are placed so as to form a magnetic field across the arc, as shown in **29**. C is the carbon electrode, which is kept slowly rotating, and M is the metal electrode, which is water-cooled by means of water circulating inside. N and S are the poles of a powerful electromagnet, and B is the battery of accumulators or dynamo. J_1, the inductance in the shunt, acts as the primary of the oscillation transformer, J_2 the secondary supplying the energy to the aerial in the usual way. A fairly large inductance, about one-tenth of a millihenry, is employed, and powerful oscillations are produced, giving an almost continuous train of waves

These oscillations can be used, of course, for telegraphy as well as telephony, and the Poulsen system of telegraphy is in actual operation between San Francisco and Honolulu, the transmission thus taking place over nearly 2400 miles.

The Poulsen Telephone Transmitter. In the Poulsen transmitter for radiotelephony the microphone is either placed in the shunt circuit of the arc or in a third inductive circuit by itself —a method also adopted by Grindell-Matthews. The effect of the speech is to alter the resistance of the shunt circuit, which appears to affect the shape of the ether waves, distorting them, as it were, or altering their amplitude, and so rendering them capable of giving up, at the receiving station, waves the distortion of which can be reconverted or reconstituted into speech. A form of detector capable of being affected by variations in amplitude must be employed at the receiving stations, and an electrolytic, vacuum valve, or special form of crystal detector is usually used.

The chief difficulty in the transmission of speech is the small amount of current which can be

passed through any ordinary form of microphone. In order suitably to modify the oscillations, fairly powerful currents are necessary if the speech is to be transmitted over any distance, and the carbon microphone used for line telephony becomes unavailable.

Here we find the solution in a fine achievement of the Italian scientist Majorana, whose *acidulated-water microphone* enables currents of very considerable intensity to be brought into play. The mouthpiece of the microphone is attached to a diaphragm which vibrates in accordance with the speech, and to the diaphragm is attached (rigidly) a small tube through which acidulated water is flowing. The stream of water falls upon two rings of metal, one inside the other, and separated from each other by some insulating material. As the water is acidulated, and therefore a conductor of electricity, the film of liquid, falling on the rings, connects them electrically, and current can pass from one to the other. The effect of speech is to vibrate the diaphragm, which, in turn, vibrates the jet of water, and varies the frequency of the drops, thus altering the thickness of the layer or film of water connecting the two rings. As the resistance of the water varies with its thickness, the movements of the diaphragm have the effect of varying the current passing between the two rings; and these variations of current, which can be rendered fairly intense, are made to influence the inductance in the transmitter.

Another similar device, due to the late Professor E. Ruhmer, is shown in 30. M represents the microphone mouthpiece, and A B the diaphragm (of mica). T is a glass tube attached rigidly to the diaphragm, supplied with acidulated water from a glass vessel (not shown). The tube, T, terminates in a fine jet, and a thin stream of liquid flows into a vessel, V, provided with an electrode, E. When one speaks into the mouthpiece, the diaphragm, A B, causes the tube, T, to vibrate, and the stream of liquid is thrown more or less away from the electrode, so altering the resistance of the water in V between the end of the stream and the electrode, E. The current which influences the wireless circuit passes from an electrode in the tank through the liquid in T, through the vessel, V, and out from the terminal, X, of the other electrode. This circuit is often placed between the aerial inductance and the earth, and the variations in its resistance vary the intensity of the electric oscillations and the amplitude of the waves radiated.

High-frequency Alternators. Besides the singing-arc method of producing continuous oscillations, we must consider the *high-frequency alternator*, which is a special type of dynamo generating alternating currents of very small periodicity. The condenser circuit used across a spark-gap fulfils its purpose by means of the alternate discharges and charges which take place, creating a number of rapid impulses. The same thing is attained by means of an alternate-current dynamo, provided it has a sufficient number of windings on the armature, and a sufficient number of pole pieces, and is driven at a sufficiently high speed. The number of complete cycles per second in an alternator depends on the number of pairs of magnet poles in the rotor and the rate of revolution. In the case of the Alexanderson alternator, a steel disc with about 400 teeth on the periphery was rotated between the poles of stationary magnets. The teeth, in travelling, diverted the magnetic flux of the magnets upon armature coils, from which currents of as high as 100,000 alternations per second were obtained.

An inductor type of machine [see page 1285] was made at the Central Technical College with 204 teeth on the rotor, which gave 120,000 alternations per second, and both Mr. Duddell and Professor Ruhmer have made similarly successful inductor type generators.

The Goldschmidt System. The most successful type of high-frequency machine, so far, is that invented by Goldschmidt, with which signals have been already transmitted some 4000 miles from Germany to Canada; and it is claimed for it that it is eminently suitable, under certain conditions, for the transmission of speech. The stator coil is excited from a direct-current dynamo, which thus creates around the coil a magnetic field, and the current induced in the rotor coil produces thus an alternating magnetic field around the rotor coil. This moving field produces in the stator a current of twice the original frequency, and in this manner the frequency is multiplied until suitable for exciting the antenna. A practical difficulty is the necessity for driving the alternator at an absolutely uniform rate, but Goldschmidt seems successfully to have overcome this and many other previous difficulties associated with this type of generator.

The Galletti System. There have been various attempts to produce high-frequency currents of great magnitude, suitable for long-distance transmission, by means devoid of moving parts. One notable instance is the Galletti system, by which method, from an immensely powerful station recently erected in France, signals have been transmitted across the Atlantic. In the Galletti generator a cycle of oscillations is produced, one after the other, with such rapidity that the beginning of the second train just joins on, as it were, to the end of the first train, and so on. High tension direct current of about 48,000 volts is employed from a series of special generators, and a large number of spark-gaps of the disc pattern are made to discharge one after the other. The original arrangement is shown in 31, but this has recently undergone some modification.

High-tension direct current from the dynamos, D, is led through resistances, R, to a series of spark-gaps, S, and these gaps produce a series of sparks, 10,000 per second or more, in regular rotation, over and over again. The high-frequency oscillations are formed in the coil, J_1, which acts as the primary of the oscillation transformer. The spark-gaps consist of a series of flat metal discs, separated by thin sheets of mica, enclosed in an air-exhausted chamber and clamped together under very great pressure.

A remarkable feature of the system is the key for switching on the current in an auxiliary circuit, in order to make the signals. This key is merely a water-jet, which can be interrupted with such great rapidity that automatic Wheatstone transmission can be carried on at high speed.

It is interesting to note that the difficulty of hearing persistent oscillations at the receiving station is overcome by forming the oscillations into groups, the group frequency being such that it is readily audible as a musical note.

Hoegerstaedt's System. Another recent system in which there are no moving parts is that of Hoegerstaedt, who places a series of coils in a rotating magnetic field [see page 1684]. As the magnetic field sweeps through the series of coils, it induces alternating currents in each one in succession; and as all the currents in *one* direction are further neutralised by means of a permanent

magnetic field, which adds to the currents in the other direction, the inventor claims, like Galletti, to produce a persistent series of uni-directional currents.

The Trend of Wireless Development. The trend of modern work is to produce persistent, undamped oscillations, as they are apparently unaffected by daylight, carry much farther for the same expenditure of power, and are far more difficult to "tap," tuning at the receiving station having to be most accurately carried out, and very perfect syntony resulting. It is highly probable that in the near future automatic transmission and automatic printed slip reception at a speed of some 200 words per minute will represent the commercial form of radiotelegraphy, with continuous oscillations. Captain Hovland, of the Norwegian Navy, has already made (and demonstrated over some considerable distance) an automatic *wireless typewriter*, with which the messages, as received, are actually printed in type. The system is capable of making use of one of several thousand different codes, so that for secret purposes it would be practically impossible to intercept an intelligible message.

The Transmission of Photographs and Drawings. Another interesting possibility is the transmission of photographs and drawings by wireless. The writer recently showed at the Royal Institution an apparatus that had been specially designed for this work.

Fig. 32 shows the transmitting device. C is a metal cylinder on which is wrapped a tinfoil sheet on which the sketch has been drawn in insulating ink. A metal stylus, T, presses on the cylinder, which is revolved with a motion similar to that of a phonograph, so that T gradually traverses in a spiral line the whole surface of the sketch. Every time the stylus comes over one of the insulating lines of the sketch, contact is broken, and the current passing from a battery, B, through the stylus and cylinder and the magnet, M, is broken. These interruptions cause interruptions at the contact, P, which acts as a Morse key for the induction coil or transformer, I, and thus the aerial, A, radiates signals in accordance with the lines of the sketch.

Fig. 33 shows the receiving apparatus. Here the signals, as "picked up," after rectification through a suitable detector, D, are passed through a fine silvered quartz fibre, W, the moving part of an Einthoven galvanometer [see page 5898]. This fibre, although only 1–12,000th inch in diameter, suffices to act as a shutter to cut off the rays of the Nernst lamp, A, which otherwise fall on a photographic film attached to the cylinder, C. This cylinder is enclosed in a light-tight box, and is rotated with the same spiral motion as the cylinder of the transmitting apparatus, and at precisely the same speed. Each signal, as received, causes the fibre, W, to shift, and so allow a spot of light (concentrated by the lens, L, shown) to act on the sensitive film. When, therefore, the transmission is complete and the film developed, a replica of the original sketch or photograph is obtained.

Both Professor Korn (the inventor of the telautograph) and the writer have transmitted pictures by wireless over short, experimental distances. When such a system is developed, it may be possible for photographs of criminals to be sent by wireless to big ocean liners on which they may be escaping from justice, or for photographs to be included in the wireless newspapers which now form a regular, everyday feature of ocean travel.

International Time-signals. The big station at the Eiffel Tower transmits daily time-signals of two kinds—ordinary time-signals sent out twice daily, at 10 a.m. and midnight, and, just previously, accurate signals by which scientific calibration of clocks can be effected. Meteorological telegrams are also transmitted at 10 a.m. and 5 p.m., special notices to navigators, and also what are termed "measure signals" for studying the variations of intensity of signals, and so on.

The ordinary time-signals are preceded, five minutes before ten, by a call signal, —.—.— three times, and then the "wait" signal, .—... The control of the actual signals is carried out at the Paris Observatory.

The scientific time-signals begin at 11.45 p.m., as a series of 300 dots, each one due to a single spark, and the 60th, 120th, 180th, and 290th are suppressed in order to facilitate counting. The method of correction by means of the signals is fully explained in an interesting article in the "Year-Book of Wireless Telegraphy and Telephony (1915)."

Wireless in Meteorology. The barometric situation in Europe, and the state of the weather as indicated by fourteen European observatories, are transmitted each day at a quarter to eleven, this report being preceded by the initial letters B C M (Bureau Central Météorologique). A code is employed in order to facilitate the condensing of the messages into brief despatches, and the full code and method of decoding the radiotelegrams will be found fully dealt with in the article mentioned above

The German station at Norddreich also sends, twice daily, time signals, at noon and midnight The wave-length employed is 1650 metres. Similar time or meteorological signals are also sent daily from Scheveningen (Holland), Carabanchel (Spain), and from various stations in the United States, Japan, Australia, South Africa, Mexico, and, lastly, from Whitehall and Cleethorpes in this country.

Amateurs will find it necessary, owing to the somewhat long wave-lengths usually employed for these signals and bulletins, to employ large inductance coils in order to receive really good signals, but these may be readily made by winding enamelled copper wire of about No. 20 or No. 22 gauge on an ebonite or well-insulated cylinder $2\frac{1}{2}$ in or more in diameter.

The inductance can be calculated in absolute units from the formula

$$L = 4\,\pi^2\,n^2\left(\frac{2\,a^4 + a^2\,l^2}{\sqrt{4\,a^2 - l^2}} - \frac{8\,a^3}{3\,\pi}\right)$$

where a is the mean radius of the coil, n the number of turns, and l the length in centimetres.

Applications of Wireless Telegraphy. Apart from the transmission of speech, messages, and pictures, almost every year new applications of wireless are being found, and, of course, many romantic claims made, which on investigation are found to be baseless.

One of the schemes most fascinating to the more imaginative type of inventor is the transmission of power by wireless. Perhaps the day may come eventually when a locomotive may be able to pick up its power by wireless from a generating station at the terminus of the railroad. At present all attempts in this direction have been futile; but the control of ships at sea from some point on the land, the firing of mines, the firing of isolated fog-guns, and so on, are already things of reality.

Motor lifeboats have already been fitted with wireless, in order that they may proceed some short distance ahead of the parent ship in foggy weather,

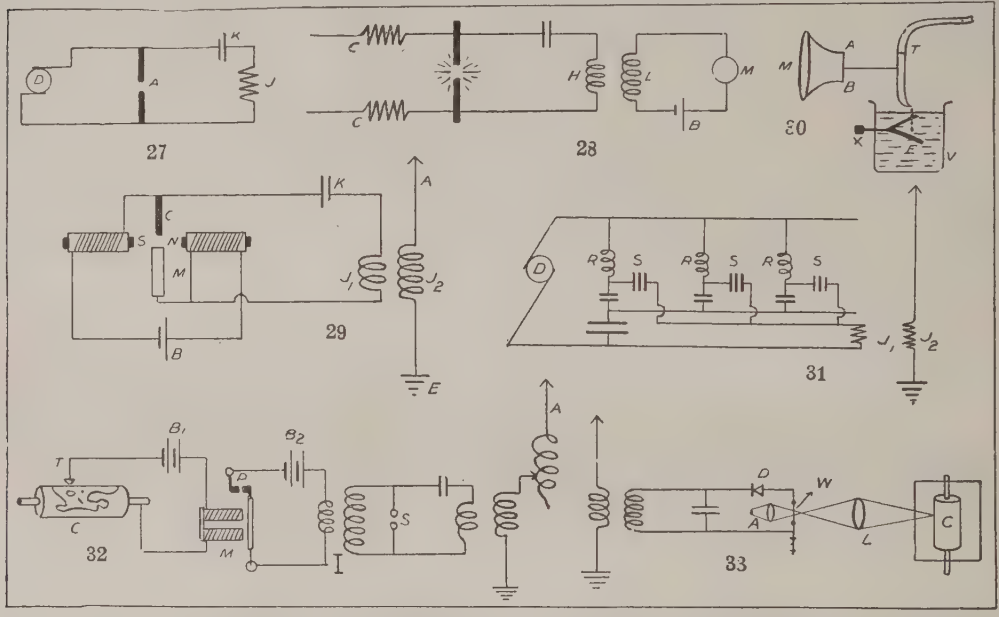
and signal to the latter the presence of icebergs. Similarly, in the whaling industry, two or three small steamers fitted with wireless usually work in conjunction with the large steamer. That a lifeboat equipped with wireless, besides being able to communicate with its parent ship, could also detect icebergs by a wireless apparatus is within the bounds of practicability.

Already wireless "explorers" are in existence for the location and tracing out of pipes in the ground, and, by means of an ingenious invention of Mr. A. W. Sharman, the position of gas-pipes underground can be traced out and distinguished from the position of water-pipes or electric mains. The Sharman *locator* consists of two parts—the generator and the indicator. The generator is a device emitting a peculiar type of electrical impulses, and the indicator consists of a framework of insulated wires. When the generator is attached to some part of a pipe which is to be traced out, one terminal of the high-frequency generator being connected with the pipe, the other with a metal spike stuck in the ground near-by, the electric impulses spread through the surrounding network of pipes, and give rise to ether waves which are readily detected by the indicator. The coil on the indicator is connected to the terminals of a double headpiece telephone; and as the indicator is held a few feet above the ground in different positions, sounds are heard in the telephone which are of maximum intensity in the immediate neighbourhood of the underground pipes. By tracing out the "line" of maximum intensity, a pipe can be located, and its depth below the ground determined with considerable accuracy. The instrument is seen in use on page 6012.

Wireless Control on Railways. Wireless fog-signalling is another new branch of radiotelegraphy which deserves mention. By it it is possible in foggy weather to control the movements of a train from a central station, the apparatus on trains in one direction being adjusted to one impulse frequency, that on trains moving in the opposite direction to another frequency, so that trains meeting would stop at a safe distance apart.

Some interesting and highly successful experiments were recently carried out at Nürnberg, in which the brakes were applied from a wireless cabin to trains travelling at forty miles an hour, and the train brought to a standstill at any desired spot. Wireless control of this type would save immense outlay in the construction of long railway lines.

Atmospherics and Atmospheric Absorption. The energy of electric waves is gradually absorbed by the atmosphere, short waves usually suffering in a greater degree than long waves. Marconi observed in 1902 that signals that carried 1500 or more miles at night-time would only carry for about 700 miles in the day. The action of daylight is responsible for the greater absorption; sunlight produces partial ionisation of the atmosphere, and renders it conductive, whereas electric waves suffer the least absorption when travelling through a non-conductive medium like the ether.



DIAGRAMS OF SYSTEMS AND APPLICATIONS OF WIRELESS

27. The singing arc **28.** Microphone acting on singing arc **29.** Poulsen arc **30.** Ruhmer's microphone **31.** Original arrangement of Galletti system **32.** Thorne Baker photographic transmitter **33.** Receiving apparatus for photographs

One of the greatest difficulties in long-distance transmissions is the natural electrical discharges of the atmosphere, and many investigations are being carried on, to be later co-ordinated and sifted out, in order to come to some more definite conclusions regarding both atmospheric absorption and atmospheric discharges.

An *atmospheric* is picked up by the antenna of a wireless station and is heard as a soft hiss or buzz in the telephone, which might be interpreted as a dot or dash according to its length. The old coherers originally used with the Morse inker sets would, of course, always respond to these discharges, which would often obliterate or render quite unintelligible the messages received. Atmospheric disturbances are always more pronounced in tropical countries. Many devices have recently been tested for "filtering out" atmospherics from the legitimate Morse signals.

Various interesting points arise in the matter of ordinary atmospheric absorption For example, in working across the Atlantic, it will perhaps be daylight at Clifden and night at Glace Bay (the Nova Scotia station). Mr. Marconi has found that the weakest signals are transmitted when the boundary between day and night is about halfway between the two Transatlantic stations. There is also a marked difference between the effects of atmospheric absorption when transmitting from north to south and from east to west.

T. Thorne Baker

THE WIRELESS OPERATOR

If not a road to great wealth, a career as a wireless operator is one which presents distinct possibilities, ever increasing with the steady growth of radiotelegraphic services, to the young man of mechanical and scientific bent who has a desire to see the world. It is one of the very few careers which necessitate no lengthy and costly training, and which, once the necessary training is completed, practically assure the candidate, without any weary waiting for an opening and without the call for a heavy premium, an entry into the salary-earning arena, where he is at once independent.

The demand for wireless telegraphists exceeds the supply of competent men: and although the end of the European war will set free a large number of operators to fill posts in the mercantile marine, the "safety of lives at sea" regulations, which come into force in 1916, will make it compulsory for every ship carrying fifty or more persons to maintain a complete wireless equipment. Each ship will require one and, where constant watch is kept, two operators to maintain service. Moreover, the number of land stations now in course of erection will each call for a staff of men.

Physical and Educational Standards. The man who contemplates a career in the wireless service must be in sound bodily health, and his hearing must be perfect. Before beginning his training he should be examined by a doctor, to be assured that all is right in these respects.

The educational standard requires a good general knowledge, the ability to read, to do elementary arithmetic, and to write clearly. Stress is laid on legible handwriting, because the operator has to write out messages without error, and without possibility of misconstruction, as he receives them. A knowledge of electricity and magnetism, of foreign languages, or of telegraphic work is not essential, but all in favour of the man who possesses it. With these qualifications the candidate is fit to enter on his training as a wireless operator, the aim of which is to secure the Postmaster-General's first-class certificate of proficiency in wireless telegraphy. There is no age limit in this examination, but, preferably, wireless operators should take their certificate between the ages of eighteen and twenty-five.

The Postmaster-General's Certificates. Under Article 10 of the regulations annexed to the International Radiotelegraph Convention, every person operating wireless telegraph apparatus on board ships registered in the United Kingdom must hold a first or second class certificate of proficiency from the Postmaster-General. This is awarded, after examination, only to British subjects.

The *first-class certificate* is granted only to fully qualified operators whose speed of working is not less than twenty words a minute. The *second-class certificate* is granted to operators whose general qualifications are satisfactory, but whose working speed is only from twelve to nineteen words a minute. Operators holding the second-class certificate are only allowed to take charge of the apparatus on ships, such as fishing-vessels, which use wireless for their own service, or as substitutes on ships which have on board at least one first-class operator. It will be clear, then, that unless the candidate is to be content with a very humble position in the new profession, he must secure the first-class certificate, for without it he can never be in charge of an important installation. The Marconi service is only open to men with first-class certificates.

The Examination. Candidates for the certificate will be required: (*a*) to send on an ordinary Morse key for five consecutive minutes at not less than the prescribed speed—the accuracy of signalling, the correct formation of letters, and the correctness of spacing will be taken into account; (*b*) to receive and write legibly at the prescribed speed from a double headgear telephone as ordinarily used for radiotelegraphic reception; (*c*) to understand simple diagrams of the electrical connections of the apparatus used in the system in which he is being examined; (*d*) to be able to connect up the apparatus with the help of such diagrams, so far as this is required in the system in which he is being examined; (*e*) to name the principal parts of the apparatus and indicate their use; (*f*) to mention the most common faults and the means usually taken to remedy them in the system in which he is being examined; (*g*) to explain the steps taken to change from one wave-length to another, in sending and receiving, in the system in which he is being examined.

The examination also embraces a practical test in: (*a*) connecting up apparatus; (*b*) operating (sending and receiving); (*c*) regulating and adjusting; (*d*) altering the wave-length; (*e*) reducing and increasing the transmitting power; (*f*) tracing faults.

Notes on the Examination. Candidates for examination must fill up and return to the Secretary, the G.P.O., London, a form of application which will be found in the "Handbook for Wireless Telegraph Operators" (to be purchased, price threepence, from Messrs. Wyman & Sons, 29, Breams Buildings, Fetter Lane, London, E.C.), from which the above regulations are taken. The fee is five shillings. The date and place of examination will be notified to the candidate. Examinations are generally conducted at the General Post Office, London, but may be held at wireless schools throughout the country if they possess suitable apparatus for the purpose. The candidate may be examined in any well-known system of radiotelegraphy, and his certificate will indicate the system or systems in which he is proficient. It may be remarked that, in this country, the Marconi service holds by far the greatest opportunities. Once the operator has mastered this system, he should have little difficulty in understanding any other with which he may come in contact. On passing the examination a candidate is required to make a declaration that he will preserve secrecy regarding all radiotelegraphic correspondence with which he may deal.

If a candidate fails in his examination he will not ordinarily be re-examined until after a lapse of three months. The holder of a certificate may have it endorsed or suspended if he be proved, to the satisfaction of the Postmaster-General, wilfully or negligently to have failed to comply with the

provisions of the International Radiotelegraph Convention and Regulations.

The sending and receiving test is conducted in the International Morse Code, five letters being counted as one word. The examination with regard to the actual regulations regarding the transmission of messages is based upon the rules contained in the "Handbook for Wireless Telegraph Operators" above mentioned, which contains the International Morse Code signals. Special importance is attached to the practical examination, for the wireless operator is in sole charge of his station, and in the event of a breakdown will have to do his own repairs, unlike the land telegraph operator, who has linesmen and engineers whom he can call to his aid. Each candidate appears alone before the examiner, who creates faults, and makes wrong connections in the transmitting, receiving, and emergency apparatus, the candidate being allowed a reasonable time in which to remedy them.

Facilities for Instruction. Having examined the scope of the examination for the Postmaster-General's certificate and the entrance regulations, we may now consider the facilities offered to the candidate for training. Whatever the system the candidate may choose to make himself proficient in, the groundwork is a thorough knowledge of the principles of electricity and magnetism. This should be familiar to the student who has followed closely the course on ELECTRICITY in the SELF-EDUCATOR A practical grasp of wireless telegraphy is only to be gained at a college or institute of wireless telegraphy where the student can handle the apparatus he will have to use. Moreover, it is essential that the student should have competent instruction in order to acquire a correct "style" of sending. In the International Morse Code a dash is equal to 3 dots, the space between the signals which form the same letter is equal to 1 dot, the space between two letters is equal to 3 dots, and the space between two words is equal to 5 dots; therefore it will be seen that a jerky or uneven style of sending may lead to great confusion, and, if persisted in, will be hard to eradicate.

Among the prominent schools of wireless telegraphy may be mentioned the London Telegraph Training College, 262, Earl's Court Road, London, S.W.; the East London Wireless Telegraph College, 228, Romford Road, Forest Gate; the British School of Wireless Telegraphy, 179, Clapham Road, London, S.W.; the North-Eastern Schools of Wireless Telegraphy, 18, Eldon Square, Newcastle-on-Tyne, 11, Church Street, West Hartlepool, and 22, Blenheim Terrace, Leeds; the North British Wireless Schools, 48, George Square, Edinburgh, with branches at 141, Bath Street, Glasgow, and Melville House, 11, Nethergate, Dundee, whose course of tuition is under the supervision of Dr. J. Erskine-Murray; the Northern Wireless Schools, 11, Lower Sackville Street, Dublin, and 47, Market Street, Manchester; the Manchester and Liverpool Wireless Telegraph Training Colleges, 27, Leece Street, Liverpool, and Carlton House, Fallowfield; the Atlantic College, Cahirciveen, co. Kerry; and the Irish School of Telegraphy, 18, Dyke Parade, Cork. The fees of these institutions vary (roughly, from about 10 to 45 guineas), according to whether day, evening, or postal classes are taken, and whether one or more systems are to be studied. Application should be made to the secretary of any institution. The courses, as a rule, are designed to make a student proficient in a year at the most, but a keen man will have little trouble in getting a grip of a system in nine months. Many students, indeed, have gained the P.M.G.'s certificate within a shorter period.

The Marconi Schools. For those who desire to enter their service, the Marconi Wireless Telegraphy Company have schools at Marconi House, Strand, London, W.C., where instruction is given during the day in both the theory and practice of wireless telegraphy, students being taught to operate, adjust, and repair apparatus of the same type as is installed in ship stations. The London school is fitted with ½, 1½, and 5 k.w. stations. A beginner with no previous business experience signs on as a servant of the company, and is paid 5s. weekly while he is undergoing this course; men who have had land line or cable telegraphic experience and can send from 20 to 25 words per minute receive 17s. 6d. per week during this trial period at the London school. After gaining the Postmaster-General's first-class certificate, and passing a qualifying examination by the company's instructor, they are drafted into the service of the company. They are then kept in the school for a short period to learn the company's clerical methods and system of accounts. From time to time as vacancies occur the newly fledged operators are appointed to ships. An operator must be prepared to go on any ship to any part of the world.

It should be observed that the gaining of the Postmaster-General's certificate is no guarantee that the holder will be admitted to the Marconi or any other service. Further, students of wireless schools who, on gaining the certificate, are accepted by the Marconi Company must attend that company's classes of instruction in clerical work and accounts.

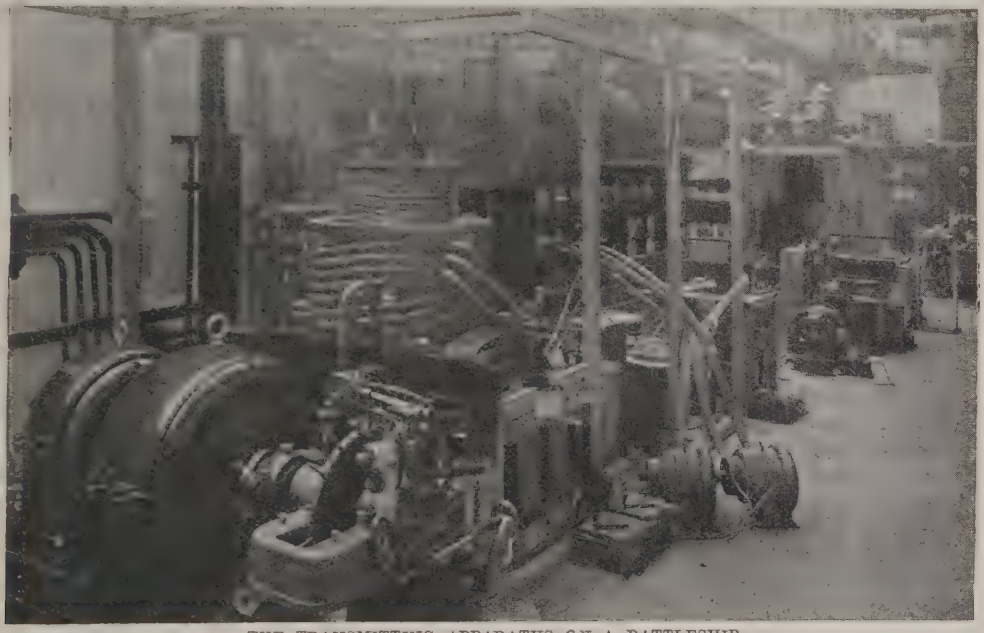
Salaries and Prospects. On being appointed to a ship as junior operator, the Marconi man continues to be an employee of the company, and receives a salary of £1 per week, with all found on board, and an annual increment in salary of 2s. 6d. per week up to a maximum salary of £1 10s. weekly, paid whether or not the ship be laid up in port and he be idle in consequence. His uniform he must buy. On promotion to senior operator, which may come rapidly with efficiency and good conduct, the salary starts at £1 15s. per week, with all found, and rises, with an annual increment of 5s. per week, to a maximum of £2 15s.

On board ship the operator ranks as a junior officer, and he is subject to the same disciplinary regulations as the crew. His work is confined solely to his telegraphic duties, except in special circumstances. Where he is in sole charge his hours may sometimes be long and irregular, but where two operators are employed, as in future will be largely the case, his duties will not be onerous. In his spare time a certain liberty is allowed him to take part in the pleasant social life on board. In the course of his duties his transferences may be rapid, from cargo-boat to liner, and to him, perhaps rather mortifying, from crack liner to some much humbler vessel. There is little cause for mortification, however. The operator of a crack Transatlantic liner has little chance to see the world; he has hardly reached port and got his accounts adjusted before he must be out and on the highway again. On the cargo-boat he will have much more spare time in port during loading operations, his salary being paid all the time.

Promotion. Subsequent promotions are made as vacancies occur, generally according to seniority. After a term at sea an operator may qualify for a

position as travelling inspector, whose function it is to make reports on operators and instruments to the head office of the company he may serve. Inspectorships bring additional pay, which sometimes exceeds £2 10s. per week. For a few men there are posts as resident inspectors, at a slightly higher salary. These officers are stationed at a port, and on them is the responsibility for seeing that the wireless installations of all ships using their system which call at the port are thoroughly overhauled and adjusted. Land station vacancies are reserved, as a rule, for picked men. Senior officers in such a position receive a salary of £250 per annum. The stations are often situated in very remote spots, and may not appeal to the operator who likes the constant change of scene that ship-life brings. Besides these, there are many branches in the company's service where a good man can be usefully employed.

One of the "plums" of the wireless service that may come in the way of a smart young operator is an appointment on board a private yacht. In such a case the pay is usually good, the company agreeable, and the work not too onerous.



THE TRANSMITTING APPARATUS ON A BATTLESHIP

The Wireless Engineer. The erection and maintenance in all parts of the world of stations, both small and large, calls for a special staff of wireless engineers, men with a sound knowledge of mechanical, electrical, and civil engineering, whose work is largely carried out abroad, and who must therefore be prepared to go at any time to any part of the world.

The task may be the erection of a small ship station or of a high-power station in some remote spot where roads may have to be made and buildings set up before the gigantic masts can be assembled and erected, the electrical gear housed, and the service got in working order. Among the qualifications demanded of applicants for posts on the Marconi engineering staff are (1) a good general education up to the age of 16; (2) a suitable general engineering education at an approved technical college or university for not less than two years, with the corresponding certificate, diploma, or degree; *and* (3) not less than two years' practical experience in a mechanical engineering workshop or other suitable place.

"With regard to the nature of the practical work," says the Marconi official publication, "the most suitable experience would include fitting, turning, forging, assembling, and outside installation of engines, including foundations and the lining up of bearings. Also, if possible, experience in the maintenance of steam plant. Experience as a switchboard or sub-station attendant is not of much use. Experience in large electrical manufacturing works is usually distinctly less useful than experience in moderate-sized mechanical engineering workshops, though there are exceptions to this rule."

Engineers of the Marconi Company, before being in charge of a contract, whether large or small, must have some experience of the engagement and control of labour, the transport of goods, including Customs arrangements, and have a working knowledge of accounts and correspondence.

The average age at which men are engaged is from 21 to 25, and occasionally applications are considered from men who have not exactly fulfilled the requirements quoted above.

An applicant who, after an interview, is considered satisfactory is given a probationary period of three months on the engineering staff, with an allowance to cover cost of living during that period, in which he is instructed in the principles of wireless telegraphy and their application. On the nature of the probation report depends whether he is put upon the engineering staff of the company. If he is accepted, his initial salary will depend on previous training and experience.

W. WIMBLEDON HILL

WIRELESS TRANSMISSION CONCLUDED—END OF GROUP 16

Making a Pianoforte. Case, Soundboard, and Strings.
How to Tune a Piano. The Building of an Organ.

PIANO AND ORGAN BUILDING

THE PIANOFORTE

One thing is bound to strike everyone who first makes an acquaintance with the manufacture of pianos—namely, the extraordinarily small amount of skilled labour requisite for their production. True, when once the piano has been put together, the greatest skill and the utmost refinement are necessary for the proper regulation and tuning of the finished instrument; but, prior to that stage being reached, only at one or two points in its progress does the piano in the making call for the exercise of great skill and experience. We speak of the daily work in the factory; the designing and calculating of improvements is quite another matter, and calls forth the powers of the engineer, musician, and draughtsman.

The most important material in the instrument is the wood. Not only does good wood give a pleasing appearance to the instrument, but it has an influence not to be underrated on the tone. The hard, close-grained woods are especially esteemed for their vibrating power. English oak, New Zealand kauri, spruce, beech, black walnut, mahogany, and American poplar are among those in common use. Seasoning is carried out with much care; and not until they have been seasoned from three to five, and in the case of woods for high-class pianos even eight, years are they brought into use. Then, having been exposed to all weathers during this long period, the sap is thoroughly amalgamated with the wood; so that, as one writer says: "When the musical wire of the piano is struck, the dried and resinous sap, broken up into infinitesimal particles, acts like so many tiny notes that sing among the fibres of the wood and help to give tone to the instrument."

Making the Case. For purposes of convenience, let us divide the piano itself into three distinct parts. First, there is the case; then we have the soundboard, with its frame and strings attached to it, and lastly we have the action, or mechanism, which transmits the blow from the finger to the string.

Case-making is a branch of high-class cabinet-making, pure and simple. Certainly, the maker has to understand the conditions to which the cases are to be exposed, but for all that it is really a branch of carpentry. As such, we need not discuss it here, save to say it is essential that the wood be seasoned to perfection, and that the curved sides of grand pianos are formed of a great number of strips of thin wood, bent and glued together, huge moulds and cramps being employed in the process. A close study of the chapters on CARPENTRY and CABINET-MAKING will put the student on the right road to learning his calling.

The case being made, it has to be polished, and again the section on CABINET-MAKING will give all needful instruction. We have, therefore, two main processes to study here, the first dealing with the material from which the sound is produced, and the other with the means by which that sound is evolved.

The Sound Mechanism. We will now take the portion of a piano devoted to the making of the sound. First, there is the back, which must be strong, to support all the material which lies on it, or which is attached to it. At the same time it must be of such a form as not to spoil the resonance in any way, for on it lies the soundboard, which forms the second division of this part of the piano. On the soundboard in modern pianos we find the iron frame, which takes up the strain of the strings, over which we have the strings, attached to pegs, passing over certain bridges and between small pins There we have the entire sound-making portion of our instrument.

The back, or under side, in a grand piano is built of well-seasoned wood, sometimes of best English oak, and occasionally, in cheaper instruments, of beech. It consists of stout framework, carefully mortised together, with bars across at different points. In English upright pianos these bars are usually vertical, and seven in number; in German pianos the bars run diagonally, as they do in most grand pianos. The oblique bars are said to give a smoother singing tone to the instrument, but they are not conducive to great durability. The making of these bars is, it will be admitted, merely carpentry. The calculation of their thicknesses, and the selection of their positions with a view to the quality of sound desired, is the work of a practical and theoretical acoustician. To this back, or under side, is attached the soundboard.

The soundboard is constructed of lengths of the finest spruce fir, similar to that of which the bellies of violins are made. These lengths are glued together with the greatest care, just as the belly of the violin is joined, and the direction of the wood is so arranged that, where possible, the entire length of both the bridges over which the strings pass shall lie on a single plank. The selection of the wood for the soundboard is a matter of much judgment, for on its resonance depends the greater part of the tone of the piano. Need we say that the wood, like that of the violin, must have a tone of its own?

A moment's thought will show us that the strings must exert an enormous downward pressure on the bridges, and therefore we must fasten the belly-bars across the under side of the soundboard to resist this pressure. The grain of these bars must run in an opposite direction to that of the wood of the soundboard itself. The bars are also necessary from an acoustic as well as a mechanical point of view. Anything like proper vibrations in the soundboard itself would be exceedingly undesirable, and these bars serve to prevent such being established other than by the vibration of the string.

Modelling the Soundboard. The soundboard, when the lengths of pine have been glued together, is the object of the most scrupulous care of, perhaps, the most highly trained man in the entire piano factory. The soundboard of a good piano has to be modelled most carefully. It is of a more or less convex shape, the rise being towards the strings, and it tapers gradually away in various directions, the thickness

being suited to the string which will lie over it. No fixed rule can be laid down for this tapering, nor for the thickness of the soundboard at any one part, each maker having his own private formula, preserved as a secret, which gives to his instruments their individuality.

After the soundboard adjuster has done his work, scraping, chiselling, and planing here and there till the wood gives out the right ring when he taps it, and till his callipers tell him his thickness all over is right, it is covered with several layers of varnish to prevent cracking and warping. The varnish used affects the ultimate tone, just like the varnish of the violin-maker, and differs with each firm of makers.

The "Wrest Plank." Above the top of the soundboard in cottage pianos, forming, as it were, a border to it, and at the lowest end of that of grands, separated from it by a small space, is a massive log of hard wood, generally made of layers of beech or oak, the grain of each successive layer running across those of the previous one to prevent splitting. This block is also very frequently further strengthened by a metal plate.

When we mention that the function of this plank is to hold the pegs by means of which the strings are tightened, the necessity for this care becomes evident. It is known as the *wrest plank*, and the pegs are called *wrest pins*.

The Bridges. Across the face of the soundboard are two bridges made of hard wood. It is through these that the vibrations of the strings are transmitted to the soundboard. The distance between them varies with the length of the string. The one farthest from the wrest plank is called the belly bridge, and is made in two parts, that taking the covered bass strings being separated from the bridge for the smaller strings. If the detached portion of the belly bridge is so placed that the bass strings have to lie over certain of the other strings, then the piano is spoken of as "overstrung." The second bridge, or wrest plank bridge, is placed close to the wrest plank, and in grand pianos the wires are pinned down to it, to prevent their being in any way shifted by the impact of the hammer, which in this class beats the string away from the soundboard, but in uprights drives it towards the belly. These bridges are firmly glued and screwed on to the soundboard.

The Iron Frame. Above all this is placed the massive iron frame, which has to withstand the enormous strain of the strings, a strain which, in large concert grands, approaches 30 tons. The iron frame is cast of the best hard metal, carefully finished by mechanics. It is attached to the wrest plank, soundboard, and back. At one end it bears the pins to which the fixed ends of the strings are attached.

Across the iron frame are bars, the direction of which differs in almost every make of piano. These are simply mechanical contrivances for enabling the frame to withstand the pressure upon it. The iron frame is bolted into its place by massive bolts and screws.

Stringing. When the piano has reached this stage it is taken to the stringer, who is often a youth destined later to become a tuner or regulator. He begins to put on the strings, placing the loop over the end pin and the free end through the hole in the wrest pin, which he then hammers into its hole and tightens up slightly.

The strings being all in place, the body of the piano passes to the "chipper up," who is an elementary tuner. This workman, or artist in embryo—for he is in the first stage of skilled work—starts to tighten up the strings into some sort of tune. To get the sound, he chips the strings with a piece of ivory, twanging them like the strings of a mandoline. He does not start at one end of the piano and work right through, but, "setting" a scale in the centre, tunes roughly from that, as if tuning a proper piano. This prevents the strain from being put on one end suddenly, leaving the other loose, a proceeding which would damage the piano. [See PIANO TUNING, page 6024.]

Stretching the Strings. The instrument having been brought into some resemblance of tune, a piece of board, covered with leather, is taken and pressed with great force up and down the strings to stretch them and, as far as possible, remove all spring in them.

After this operation it will be found that the tune has vanished, and so the piano must be re-tuned, being brought almost up to pitch. It is then left for a few days, and then again tuned to pitch. Four or five such tunings will be necessary before the tune will stand, and only then is the piano ready to be tried with the action. This chipping up is generally done after the back, soundboard, and so forth, have been firmly screwed into the case which is to contain them.

The Action. Very few piano-makers in this country make their own actions; unfortunately, most of them depend on the Continent for the supply of very second-rate mechanism. A few firms, however—not half a dozen, alas!—prefer to manufacture their own, and the result is that their pianos contain sounder and better actions than any made abroad.

The bulk of the action for the best English makes of pianos is cut out of the finest and hardest French hornbeam, a wood with very little grain, and one which works as cleanly as metal. It is little affected by moisture, and consequently actions made of this material rarely stick, provided they have been properly made. Foreign actions, produced in a violent hurry and badly finished, manage to stick, even when made of hornbeam. Beech is used for a few parts, and English oak is used for the action rails running right across the piano, against which various portions rest, or to which portions are screwed.

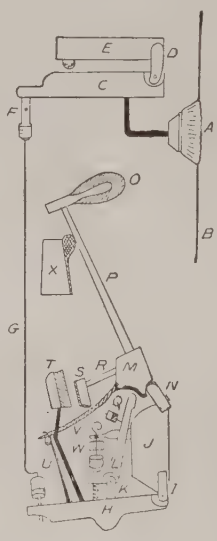
Of actions there are many, but as examples we will take two typical actions for upright pianos—namely, the over-damper check action and the under-damper check action, with a tape. These are named according as the damper is over or under the hammer. Of actions for grands we shall not treat, because, until the beginner has mastered the fitting and regulating of upright pianos, he will not be entrusted with the more costly action of a grand. We will, however, indicate the principle upon which the grand action works.

The actual making of the component parts of an action is accomplished by machinery, the work being so subdivided that unskilled labour can be employed to an enormous extent. Thus, one operative will do nothing but pass wood into the sawmill; another will be solely engaged in boring holes in one particular part of the action; a third will give the correct bend to the various wires used, and so forth, each operation being performed on machines fixed to an exact gauge, so that error cannot possibly creep in. Only when all the individual parts are ready to be assembled does the skilled man step in.

Where, then, does the superiority of the English action come in? In attention to detail, and in the quality of the accessories which are indispensable

to the proper making of actions. We will indicate one small particular. The holes through which the tiny wires which act as hinges for the moving parts of the action should be lined, or "bushed" with cloth. In Continental actions this is never done so efficiently as in English actions, with the result that, after a time, the mechanism rattles, and rebushing becomes necessary if the piano is to work properly.

Over damper Actions. The portions of an over-damper check action are best understood by reference to the accompanying diagram [1]. It will be seen that there are in reality two distinct motions, to be accomplished by two sets of levers operated initially by the primary action of the end of the key lever. The first motion is the withdrawal of the damper A from the string B, by the combined actions of the damper lever C, which is hinged on to the damper flange D, and checked in its turn by the damper rail E, to which also the flange is screwed. All flanges and parts screwed to fixed rails are fastened by one screw only, but, to prevent them from shifting, are provided with a groove across them, into which fits a raised bead on the rail. The damper lever is lifted by the damper lifter F, moved by the damper wire G, which passes through the base of the end of the jack rocker H. The wire is free in its hole, and has its button screwed upon it, on which the jack rocker presses to lift it. When the sustaining or loud pedal is pressed, by an arrangement not shown in the diagram, C is lifted, and so the dampers are moved away from the strings. The end of G, being loose in H, enables the jack rocker to move, when the key is struck, without affecting the damper at all. At the knob shown on the lower part of the jack rocker, a rod is fixed, which is pushed up or down by the direct action of the key.



1. OVER-DAMPER ACTION
[For explanation, see text]

The jack rocker may then be considered as the junction of the two systems of levers. It is hinged by means of the jack rocker flange I to the hammer flange rail J. Almost above the lower protuberance in the diagram is fixed the jack flange K, carrying the jack L, the upper end of which presses on the hammer butt M. The hammer butt is fixed to the hammer flange rail J by the hammer flange N, and on being pushed upwards by the jack, tilts the hammer O, carried by the shank P, against the string B. The little spring under the foot of the jack is to keep that part close against the hammer butt, and the jack is prevented from coming too far forward by the jack check rail Q, seen in section. The felt on this rail is adjustable by means of a screw. R, S, T, U, and V form the check system, and are named respectively the back check shank, the back check, the back catch—on which the back check hitches when the hammer is far enough forward, and which regulates the rebound after a stroke—the stirrup wire, and the tape. The tape keeps the hammer from going too far forward, or from sticking close to the string after the key has been raised. W is the escapement rail, with screws and buttons for regulating, and X is the hammer rest, covered with padding against which the hammers lie.

Each of these distinct parts is made separately, and only assembled at the last minute. The curved and shaped pieces of hornbeam are first of all planed to shape with moulding planes, a whole strip some 6 ft. long being dealt with at a time. This is then cut up into sections by means of a revolving saw driven at very high speed. The sunk grooves, where the joints work, are then cut to a regular depth by another machine cutter, the depth being regulated by gauge. After this, the holes for the pins are bored, and then the holes are lined or bushed.

Lining the Holes. The bushing is done in this way. A strip of superfine cloth, known as "Mechanics' Cloth," and costing about 20s. a yard, is prepared of such a width that if forced into the hole its edges will just meet. These strips are cut by machines. The strip is rolled up spill-wise and the point drawn through a hole, and then through a second, and so on, till the strip of cloth is threaded through as many pieces of bored wood as will go upon it easily. Just as the cloth is drawn through the outside is slightly smeared with paste, to hold the bushing in the hole. When the strip is full, the various sections of wood are separated from one another by cutting the cloth with a sharp chisel, and when the edges are trimmed the holes are all neatly bushed. The bushing is then just opened for the pin by means of a needle. The shanks are made by drawing strips of wood through a revolving series of cutters, the strip emerging as a round stick, which is subsequently sawn up into lengths.

The base of the hammer butt, where the jack impinges, and the face of the back check are faced with very fine doe skin. This skin is far better than sheep skin, which is commonly used abroad. It must be shaved down to one regulation thickness before being cut into strips for the purpose of being glued into place. It is often advisable to fasten a piece of thick felt or cloth behind corners covered with this leather, as the shock is thereby softened, the action improved, and the life of the leather greatly prolonged. The felt for the hammer head is woven specially to a taper, and only requires bending and gluing into position, being pressed down with heated curved irons.

Fitting the Action into Position. When sufficient sections have been collected to make up an action a fitter builds them into position, by screwing the various flanges on to the rails attached to the action frame, which is made to fit the particular piano to be completed. Then he sees that each individual action works smoothly, and by means of the regulating screws gets all the levers to have about the right amount of play, leaving the final regulating to the expert later on.

In another part of the shop the keys have been sawn out, and the ivory or celluloid attached. Ivory, of course, cannot be bent, but celluloid can be bent by heat, and thus made to cover the top and ends of the keys. The holes for the pins and pivots are bored by machinery and the portions of the keys which play on the rod of the jack rocker burnished with black lead, or covered with felt or leather, according to the method employed by the particular maker. Then the keys have holes bored in them and lead weights inserted, of sufficient size nearly to balance the entire key at the pivot when in contact with the action and the

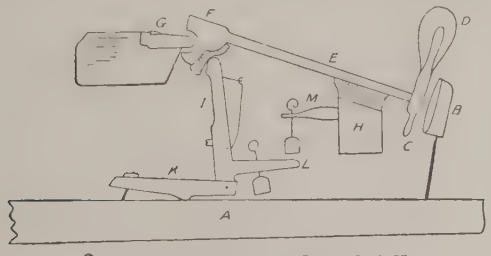
hammers lying back. The damper lever of over-damper pianos is also generally weighted, to ensure the damper falling forward on to the string as required. These weights are cast so as exactly to fit holes bored in the wood for their reception. The fitting must be done very neatly, lest a rattle should be set up.

All these adjustments having been made, and the keys placed on the key bed, and brought to a proper level by means of washers, or punches as they are sometimes called, placed under the keys round the pins, the action can be placed in position in the piano, and the instrument handed over to the regulator. At this stage the rail which is to lift the dampers is connected to the pedal levers which have been fitted inside the case, and the damping felt can be attached to the action, if the soft pedal is to be operated in that manner.

Under-damper Actions. The under-damper action, which we illustrate [3], is very similar to the over damper, save for the actual damping arrangements. The lettering of the hammer and check mechanism will, therefore, remain the same as in the previous illustration. The damper alone will claim our attention, together with the means of operating it.

In this action it will be noticed that the damper is inside the hammer mechanism, and the damper lever, which is in one piece, and marked A, is operated by a portion of the jack rocker on the opposite side of its hinge to the hammer mechanism. Did the end of the jack rocker touch the end of the damper lever, then, when the key was depressed, the end of the rocker would fall away from the lever. This would not work the damper. The damper lever is attached to the hammer flange rail by the damper flange C, and the lever has a small spring bearing against it, just sufficiently hard to press the damper firmly against the spring. The end of the lever, near the rocker, is covered with fine leather, and sticking upright in the end of the rocker, lying close to the end of the lever, is a small metal rod, flattened out into the shape of a spoon. This is marked Y.

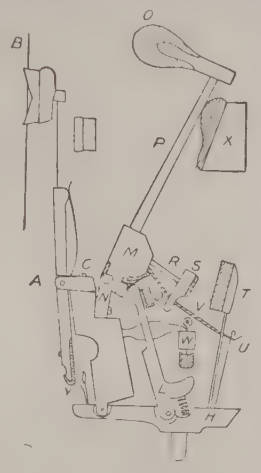
By means of a screw passing through the bottom of the lever the leather facing can be made exactly to graze the smooth surface of the spoon when the hammer is at rest. If, now, the jack



2. SQUARE AND GRAND ACTION
[For explanation, see text]

rocker be lifted by the depressing of a key, the end of the rocker beneath the lever will fall, but in so doing will thrust the spoon a little forward. The forward movement is not very great, but it is sufficient to enable the spoon to press against the leather-faced end of the lever, and so to lift the damper off the strings. On the key being released the spring returns the damper to the string. In this class of action the loud pedal mechanism may be of any kind which will press the entire set of dampers back from the strings a fraction, and may operate either above or below the damper flange.

Actions for Use in the Tropics. There is a new pattern action, invented in the past few years, for fitting to instruments intended for use in hot climates, which is excessively simple, while at the same time it is most efficient. In it the key acts directly on the jack rocker; the jack is very long indeed, and carries two projections on it at an interval of about 1½ in. distant. The lower one operates an over-damper action of the pattern shown in our former diagram. The inner and upper one carries the back catch, which in this case has the felt facing outwards. The hammer butt carries the back check, which is on a wire bent over the back catch, and with the leather facing turned inwards. The top of the jack acts direct on the hammer butt. By this means it will be seen that the friction, and consequent sticking points, are brought to a minimum, and there is much less padding for insects to destroy. The touch of these frictionless pianos is very delicate and they are fast becoming popular. In place of a tape, a small loop is attached to the hammer butt, and this hooks into a curved spring fixed in the upper part of the jack, the spring serving the double purpose of pulling the hammer back, and keeping the jack close up against the butt.



3. UNDER-DAMPER ACTION
[For explanation, see text]

Grand Piano Actions. The actions of grand pianos, as we have already said, are exceedingly complicated, but the principle which underlies their construction can be gathered from our diagram [2], which represents the action of an old square piano. It will be noticed that the key itself carries the back check, and the back catch is a prolongation of the hammer head in a downward direction. The jack rocker rests directly on the key lever, and the escapement lever, with its button and screw, also acts on the key, and, as well, on the set-off button attached to the escapement rail. The damper, which is above the string, may be raised by a wire fixed into the key lever at any point between the rocker and the back check. The parts are these:

A is key lever; B is back check; C is back catch; D is hammer head, and E hammer shank; F is hammer butt; G is hammer flange; H is hammer rail; I is jack, with spring and silk loop passing through jack or round it and attached to hammer butt; K is jack rocker; L is escapement lever and regulating button; and M is escapement rail with regulating button, or set-off button.

Regulating a Piano. The first thing the regulator does on having a piano handed over to him for adjustment, be it old or new, is to see that all the keys are perfectly level. If they are not, he places paper or cloth punchings, or wads on to the centre pin till all are exactly level. This will not,

as a rule, be necessary with a new piano, but it is mentioned because it frequently has to be done to old instruments. If the keys are too loose on the front holes the oval guide pins can be turned a little till they have free play, but are not able to shake. The depth of the touch is then tested. It should be about $\frac{3}{8}$ in. deep in the middle registers and about $\frac{1}{32}$ in. deeper or shallower in the bass and treble respectively. The correct depth can be arrived at by placing cloth or punchings under the middle rail to make the touch deeper, and under the back or front rail to make it shallower.

The Position of the Hammers. The regulator next sees that all the hammers are level and properly spaced, so that they strike the strings fairly. In a new piano, made with an English action, he will not find alteration necessary; but when a foreign action is fitted, he may have to shift one or two hammers a little. The jacks must next be adjusted close under the notch in the hammer butts, and this is done by turning the regulating screws; but the jack must not be raised too much or the note will fail to repeat in rapid passages. The proper position is immediately under the notch, just touching it lightly, so that the slightest touch on the key raises the hammer.

Next, the "set-off" must be seen to. The set-off of a note is the distance to which the hammer is raised by pressing down a key. In a properly regulated piano the hammer should advance to within a quarter of an inch from the string in the centre notes. In the bass it should be rather farther away, and in the extreme treble a little closer. Only experience can teach the exact ideal positions. The set-off is regulated by turning the regulating screw with a small hook till the hammer advances the proper distance.

That done, the back check and catch must be arranged by bending the wires till the check just catches the hammer and holds it for a second when the hammer rebounds from the string; this is to enable the jack to recover itself and get into the notch beneath the butt again. At the same time the check and catches must be adjusted so as to prevent the hammer from falling back too far from the string. About twice the distance of the set-off is correct, though some make the hammers fall back to $\frac{1}{2}$ in. all over the register. This must be properly adjusted or else the piano will not repeat with accuracy.

The damper action must next be seen to, and in an over-damper the wires should be adjusted by turning the buttons so that there is a play of about $\frac{1}{32}$ in. between the button and the end of the jack rocker. In under-damper actions the dampers do not often require touching, being adjusted in the shop. If, however, the dampers do not lift readily, or if they lift too much, the screw which passes through the lever end and presses the felt or leather out towards the spoon can be turned till the damper is correctly moved by the depression of a note. There should be a little space between the spoon and the lever tail when the action is at rest. Next, the action of the pedals must be seen to, and any friction overcome by using blacklead. When all works smoothly, it is time to tune the piano.

PIANO-TUNING

In all keyboard instruments tuning is a far more complicated process than it is, for example, in the violin, which has but one string for many notes, and not more than four strings altogether. In the piano, instead of four lengths of catgut, there may be upwards of 200 steel wires strung across an iron or steel framework, the total tension, according to the size of the instrument, being approximately from 15 tons to 30 tons. Attention to so many strings would alone demand more time than any professional pianist has to spare.

Unisons. The knowledge most usually required is that for pulling up and adjusting a new string. First, the broken string must be extracted. To do this in an upright piano (we are not speaking of grands), take off the front. First turn the buttons inside the top panel at the bass and treble ends; draw the front forward, lift it out; turn back the cover or cylinder over the keys, and lift it out. If the front and cylinder are joined, both come out together. To remove the action (or hammer mechanism), turn the buttons at either end of it, or undo the thumbscrews. Grasping the hammer rail, draw forward the action. Lift it up out of the sockets and place it on a table, or in some other convenient position. Unfasten the catches under the keyboard. Draw the bottom door forward and take it out. In an upright piano, the gauge for strings varies from treble to bass, from No. 9 to No. 21, the sizes of wire being marked below the tuning-pins. In a trichord cottage, the pins are placed in threes, one over the other. If one string serves for two pins, the bottom pin of one note and the top pin of the next, or the two middle pins of neighbouring notes, will need new wire. Having obtained the necessary length (by sending the old wire to a maker as a pattern), bend one end of the steel into a loop $\frac{1}{2}$ in. long. Twist the end round twice, and clip it off with a pair of cutting pliers.

"Chipping Up." Place loop on hitchpin, projecting from the iron frame at the opposite side to the tuning-pin. Fit the string between the two pins in the bridge, alternately inside the first and outside the second. Pass the wire up above the keyboard. Thread the string through the hole in the brass stud, if necessary. Cut off the wire with the pliers 2 in. beyond the position of the tuning-pins. Insert the string through the eyehole of the pin. Put the tuning-hammer or tuning-crank on the latter; twist the pin round twice to the right, making the coil even. If the tuning-pin has been taken out of the plank, drive it in with some smart blows from a hammer till even with the other pins. Now turn the hammer round to the right, "chipping up" the tone of the new string with a piece of bone or a mandoline plectrum until it is in unison, as regards pitch, with the other wires belonging to the same note. After taking off the hammer, replace the action. With the right hand, readjust the hammer to the tuning-pin, and with the left try the note on the keyboard. Listen attentively to the throbbing of the vibrations. Gradually turn the hammer to the right until the quick and uneven beats merge into one steady and clear sound.

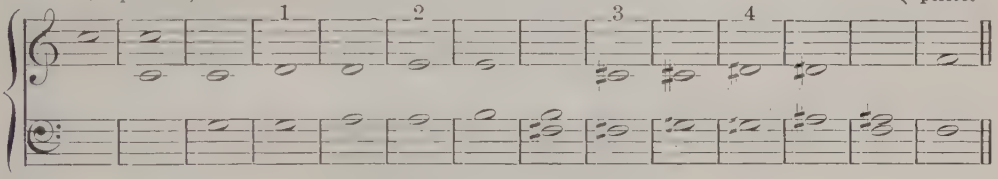
An identical tone is the easiest for the student to begin with. In trichord pianos, where three strings go to each note, two-thirds of the total are so tuned. When the throbbing has resolved into a steady vibration, the new string will be in unison. To ensure that the note will stand, "set" it by striking the key sharply to ascertain that the wire does not slip through the stud nor over the bridge. If it does, repeat the tuning and the proof till the note holds firm.

Octaves. If a new string put on is a single one of covered wire in the bass (the steel core being overspun with copper), it must be tuned by the octave note above. Strike these two notes together. In point of importance and facility, the tuning of

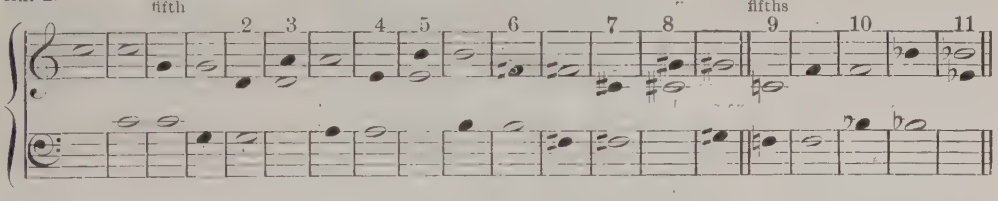
the octave, so far as the student is concerned, comes next to the perfect unison. Though no longer identical, the sounds resemble each other strongly. Turn the hammer on the pin of the new string gradually to the right. Listen attentively. At first the beats will be uneven. When the lower string reaches its proper tension, the two sounds will cease to vibrate unevenly, and the compound tone then produced will blend smoothly. Take care not to raise the new string above the pitch required, or it may break; neither put any side pressure on the tuning-pin, or it may snap off. Avoid turning any pin unnecessarily, otherwise it may become loose, and naturally a piano with loose pins cannot stand in tune.

"Laying" a Scale. In this country tuners generally lay the scale from C (third space, treble clef). On the Continent the start is made from A (second space, treble clef). It is the tuning-fork, therefore, which gives the initial tone. The correct pitch of the latter is thus of paramount importance.

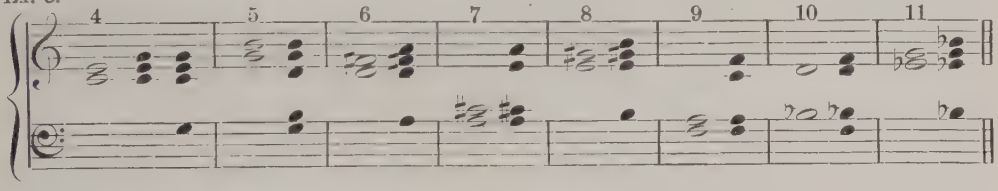
Ex. 1. Pitch C — Octave perfect — All fifths a wave flat — Octave perfect



Ex. 2. 1st fifth — Back fifths



Ex. 3.



Pitch-pipes are not recommended, as they are frequently inaccurate. What is known as *concert pitch* is a nebulous term. In England there is the Kneller Hall sharp military pitch, the low French pitch, and the Society of Arts (or medium) pitch between the two extremes, besides other fanciful standards used by various piano-makers. Accurately measured tuning-forks are difficult to get at an ordinary music-shop. The point is to get a fork at the new pitch (stamped "C 522" double vibrations per second), not the old Philarmonic pitch (C 540), as the latter is considerably sharper, and puts a greater tension on the strings of the piano, as it does on the voice of a singer. In addition to a tuning-fork, when tuning a trichord instrument three wedges are needed. These consist of narrow strips of whalebone, or pliable wood, ¼ in. wide and 9 in. long. The ends are padded with one or more layers of wash-leather, the thick tip being for unisons and the thin for octaves. From the front, carefully insert a wedge obliquely through the action, so as not to touch the hammer striking the note to be tuned.

Having wedged out two of the three strings of pitch C, put on the hammer. Sound the tuning-fork by striking one of the blades smartly on the knee with the left hand. Place the small end of the fork on any portion of the woodwork in front of the piano. To the sound it gives, C, third space, treble clef, must now be tuned. Raise or lower the pitch of the string gradually until, when the note C is struck, it agrees accurately with the tuning-fork. Stop the vibrations by a wedge inserted between two of the unisons of the C below, and get the octave perfect. Do not strike the lower note too hard at first. The sharp blow is only required for "setting."

There are various ways of laying the bearings of a keyboard instrument. Different tuners naturally pin their faith to the methods which they have been taught and have found most useful. But as all these systems, properly carried out, have the same result in making the tone of the instrument agreeable musically, the student may adopt any one of them profitably.

"Tempering" Notes. Presuming that the pupil is musically inclined, it may surprise him to be told that the foundation of the tuning of all our keyboard instruments is intentionally inaccurate. Let him look at the piano for a moment. Enharmonically, every white and every black note has two names, if not three. C natural serves also for B sharp and D double flat; C sharp is also D flat; D natural likewise is C double sharp or E double flat, and so on. Therefore, if we have twelve keys within an octave, we have to make them serve for upwards of twenty-four notes indicated in music. A very clever violinist with a sensitive ear, or a trombone player, because the tone of such instruments is not fixed, will play in what is called "just" intonation. On a pianoforte or church organ, the only intervals *absolutely* perfect with the pitch notes are the octaves. The rest of the notes are "tempered." For the purpose of practical

harmony, the notes within each octave have been so modified that the acoustical divisions between them have been made as equal as possible.

The ear of the musical student may at first rebel against the mutilation of any interval, but the system of modifying the notes within the centre octave internationally adopted is based on common sense, and has been found the only possible solution of a problem which perplexed musicians for many years. Mathematicians, acousticians, musicians, and manufacturers have written libraries full of books on this subject. It is therefore a difficult one to deal with succinctly, and the reader is referred to Example 1.

After tuning the octave C, it will be seen that the student must proceed to G below. Tune the fourth perfect. Then from this G get the fifth above, D, "tempering" it by leaving it a beat flat. From the D tune the A below a perfect fourth. Then get the second fifth by tempering the E above a shade flat. Tune the B below a perfect fourth. From the B go down to F sharp, and make that also a perfect fourth. Now get the third fifth by tuning C sharp a wave flat. Follow with the fourth below G sharp in just intonation, and then, from the G sharp, get the fourth fifth, or D sharp, a shade flat. Proceed to A sharp, a perfect fourth, and then get a fourth below the A sharp, technically E sharp but actually F natural, and, finally, tune the octave F above perfect.

Unless the "shading" has been distributed equally, the octave will not come out perfect, and to proceed any further with the tuning will only magnify the shortcomings of the bearings. Before equal temperament (advocated by the great composer Bach) was adopted, it was disagreeable, on account of the "howlings," to play the piano or organ in the "black keys"—now the most beautiful. As accurate "tempering" is an art which a beginner cannot learn immediately, his first attempt, when proved by the final octave, has no doubt revealed that his modifications of the fifths have been overdone. Let him, in going over the work again, therefore, check it in a different manner [Ex. 2].

A HANDSOME ORGAN
(Photo Bedford, Lemere & Co.)

Here the scheme includes all the keys on the piano between F natural (fourth space bass clef) and C (third space treble clef). But instead of four fifths presenting themselves, the student can check his work by eleven of them. After the low C, tune the G above a little flatter than perfect. Then prove this with the octave G below, already tuned. From that G, get the second tempered fifth, or D above, and then the third, or A above the D. Now prove this note, which should be a perfect octave with the A below, already tuned. Go over the fourth fifth that now occurs, by checking the E already tuned under the first scheme. Now, get the B above, tempering this fifth fifth a wave flat, and from it prove the octave B below, already tuned.

Next get the sixth fifth, or F sharp above, and from that prove the F sharp below, already tuned. Check again the fifth above low F sharp, with the C sharp tuned according to Ex. 1. Continue to get the eight fifth, or G sharp above, proving it with the octave note below, already tuned. Having arrived at the eighth fifth of the series, the student must return to C. Tune the remaining fifths "backwards," first making the bottom note, F natural, a perfect fifth with the C, and then slightly sharpening it in the same degree that the upper notes were flattened when tuning the other fifths "forwards." By this means the necessary tempering is done correctly, but the lower note is affected rather than the upper. Then get the octave F above perfect. Treat the B flat below in the same way, so as to modify the lower note, and keep the upper one just. Get the octave B flat above, and, finally, tune the eleventh fifth, tempering the lower E flat. Of course, as we have first seen, it is not necessary to tune all these fifths in laying a scale, and there are other ways of checking correct equalisation than the scheme last referred to. As soon as the fifth marked "4" in Ex. 2 is reached, the C below gives the major third; and if this third is slightly sharper than perfect it is an indication that, so far, the tuning is correct. In like manner test each subsequent fifth by means of the triad [Ex. 3].

Extending Operations. Upon the bearings laid the rest of the tuning is built up. The unisons, or two other strings, of each first one already tuned must be made to accord (altering the position of the wedge) until each group of three strings blends properly together in sound. This done, proceed to the octaves. Begin on C sharp (first ledger line beneath treble clef), and tune in succession one string of every octave note above until the extreme treble of the keyboard is reached.

All octaves must be "perfect." Then take the E below middle C, and tune each successive note in octaves down to the extreme bass. This done, go over the treble octaves again, as they are apt to fall in pitch as the tension increases on the lower part of the frame. Finally, try together double octaves, to see that all are accurate. Having adjusted all these notes on one string of each group of three, proceed to tune in unison the second and third string of every note. Taking these separately, adjusting the wedges as explained, get all unisons correctly above and below the central octave. To get increased brilliancy and fullness, some tuners pull the high notes a shade sharp, and leave the extreme bass a trifle flat. On completion of the work, clean the keys with a soft cloth slightly moistened with warm water, and replace the front.

Apprenticeship. In every large piano factory labour is much systematised, so that one instrument passes through many hands, each man being a specialist in his own branch. Particular attention is always given to the tuning department, because the best-made piano in the world badly tuned will sound at a disadvantage beside one of inferior make finely tuned. But to take off experienced tuners to teach beginners deprives a factory of skilled labour which has a definite

value. Therefore, considering how difficult it is to find remunerative employment for many young men nowadays, the privilege of being taught the art of tuning is gladly paid for by parents when their sons are indentured as apprentices. To acquire the necessary flexibility of finger and perception of wave-beats for good tuning, it is essential to begin in early youth, when a lad is still growing. When the wrist is once set, it is seldom possible to make what is known as a fine tuner. The usual age for beginning is sixteen. Obtain an introduction to the manager of some well-known factory and get put down in the "waiting" list. Premiums vary from £5 upwards. Apprenticeship is usually for seven years.

Entering the Factory. The first work is to assist with odd jobs the qualified tuner who acts as instructor, when not employed in "chipping up." By keeping his eyes open the young apprentice can learn much in a factory in many departments, as his work will not always be in the same shop. "Rough" tuning is generally done in the noisier departments where, in case-making or marking off, there may be a good deal of hammering, and a sub-tropical atmosphere. As the lad improves in his work he will be promoted to quieter regions, giving him an insight into hammer-covering, and ideas as to the latest method of polishing. After a certain length of useful service the beginner will receive a small weekly salary. According to ability to tune, this will rise from 5s. to £1 a week.

When the term of apprenticeship expires, an ambitious young tuner will endeavour to get a few years' outside experience. Vacant situations are announced in the various musical papers. Consult the foreman tuner, or factory manager, regarding the status of advertisers before accepting any offer. After an apprentice has done well, the manufacturer will usually be agreeable that he should seek to improve himself practically in some music-shop, where he will come into contact with instruments by other makers, and learn to repair harmoniums, American organs, or piano-players in a way seldom possible in any one factory.

Concert Piano Tuning. The laudable ambition of many a young tuner is to do concert work. This, of course, demands the most artistic skill. Having gained outside experience and, subsequently, been received back on the staff of the firm where he was apprenticed, he will find, if the opportunity is given him, that concert tuning entails considerable responsibilities. It involves, during a tour, the constant packing and unpacking of a heavy iron grand, placing it in and removing it from various provincial halls, besides attending each performance after smoothing over the tuning of the instrument. At the concert it is the duty of the tuner to open and shut the piano before and after each solo, and turn over the music in concerted pieces. Yet it brings him into personal contact with some musician of distinction whose good word may be of considerable value. The weekly wage will probably be £2 2s., with an allowance for travelling and hotel expenses. A report should be made on each concert and sent by postcard to headquarters.

THE ORGAN

Organ building is a branch of the trade by itself. It is sometimes held to be the highest branch, but only on the grounds that the organ is the largest of instruments, for though the work in organ building must be accurate, the same exactitude in measurements is not necessary as that essential in making, say, a violin or an oboe. The organ builder, however, must add to his other qualifications that of an engineer and architect, for he has, as a rule, to build his instrument to fit some selected spot, and cannot make his instruments to any regulation shape or pattern. The trade is of such magnitude that we shall not attempt to do more than indicate the general principles followed, and we shall have to assume that the reader is a first-class carpenter to start with. Such he can become by studying the articles on that subject in this work [see CARPENTRY].

The organ builder, let us assume, has received a specification for an instrument to be constructed. The specification is a list of stops required, of mechanical accessories, and of methods of blowing, and so forth. The first thing to do is to plan out his organ, after taking measurements of the space which is at his disposal. Let us suppose that the space to contain the instrument is ample, so that he can build to suit himself to a large extent.

Now, an organ consists of bellows, a windchest, a soundboard, action for letting the wind into any particular pipe when the key is depressed, and mechanism for bringing various sets of pipes into use, and, lastly, the pipes themselves which give the notes.

The Question of Size. The size of the organ depends on the number of pipes to be used—that is, on the stops with which it is to be provided, and, if proper space is permitted, to avoid any makeshift arrangements, the general size of the organ will be regulated by the size of the soundboard, or soundboards, for the pipes stand on the soundboard. The organ may be entirely built on one very large soundboard, the great organ pipes being at the back and sides, the swell in the middle, covered by the swell box, and the choir, if there is one, in the centre and front; or each of these manuals, which are in reality separate organs, may have its own soundboard, as do the pedal pipes in most organs. So the organ builder, knowing the dimensions of the pipes of each stop, sets to work to make careful drawings of his soundboard, and so to arrive at the necessary measurements for it. Around this soundboard, or number of soundboards, the organ is built up.

The Pipes. The pipes of an organ are of two main classes—namely, wood and metal. The latter are divided into flue pipes and reeds, according as their tone is produced by a whistle-like mouthpiece or by a vibrating reed. The metal pipes are made by a special class of workmen, and are to be bought, or the organ builder makes his own from the sheet. They all have the familiar form, and differ only in length and voicing. The wooden pipes are also of two classes—namely, stopped and open. A stopped pipe gives the same note as an open pipe of double the length, and, as a rule, the stopped diapason is the most bulky of the stops placed on the main soundboards. This set of pipes, then, is first of all aranged for, and then the rest of the board divided up to suit the remainder of the instrument.

How a Wooden Pipe is Made. Making a wooden pipe is simply a matter of good carpentry. The parts are these: A foot, which is a conical, wooden tube, turned in a lathe and bored right through; a block, which closes the lower end of the pipe, and into which the foot conveys the wind to a channel cut across it; and a tube, formed of three pieces of board fastened to the back and two sides of the block, and a fourth with a bevelled edge attached to the edges of the two sides and coming just down to the top front edge of the block; and a

cap, which is a block of wood the size of the block, only broader by the thickness of the two boards. This has a wedge-shaped depression cut in it in such a manner that when applied with the hollow side inwards to the face of the block the thick end of the wedge may receive the wind from the channel and distribute it across the bevelled lip of the front pipe, producing a note. These are glued together, save in very large pipes, when the sides may be screwed to the block, and also the cap screwed on. In stopped pipes there is also a stopper which, when covered with leather, exactly fits the interior of the tube. This stopper has a handle which enables the tuner to pull it in or out at his pleasure.

With minute variations, all wooden pipes are constructed like this, though some have sides like inverted pyramids, and one or two rare stops have actual pyramidal pipes.

The Soundboard. The soundboard consists of a shallow box, divided internally into as many transverse grooves as there are notes on the keyboard, or pedal board, as the case may be. The pipes stand upon holes bored through the top of the box into these channels. The top of the box is made of two layers between which lie long strips of wood at right angles to the channels beneath, and directly under each set of pipes. The holes are bored right through the two layers and the strips, and thus it is clear that any wind in the channels can pass into the pipes above and make all sound. But if one or more of the layers be pulled out, or pushed in for an inch, a plain portion of the wood will intervene between the two bored layers, and the entire range of pipes standing above the layers thus shifted will be silenced. The drawing out or pushing in of these slips is controlled by the stops; when the stop is pulled the valves are opened, and closed when the stop is pushed back. In making this arrangement, the joinery must be perfect and the intercepting sliding parts accurately fitted lest the wind escape, and the tone of the organ suffer.

The upper table of the sound-box is conveniently made from sound boxwood, and the bars forming the sides of the grooves of good pine. The slips of wood which govern the admission of air to the ranges of pipes are cut from good pearwood, or other similar hard wood. They are termed sliders. Between each pair of sliders are strips of wood to prevent the air passing to a neighbouring set of pipes. These are termed *bearers*, and are glued between the two upper boards. It is needless to say that the upper boards need not be of the entire size of the soundboard proper, but may consist of a series of shallow boxes on the top of the soundboard, with the sliders and bearers enclosed within. This is a saving of wood. Also we need not point out that the upper board and sliders for small stops need not be as large as for heavy bass stops, such as those of 16 ft. pitch. The holes are bored through the boards, sliders, and soundboard with good centre-bits or augers.

To support the pipes a certain number of rack boards have to be prepared. These take the strain off the soundboard, and serve to maintain the pipe in an upright position. The holes in the rack boards have to be very much larger than those in the upper board, because they are eventually fixed on legs 5 in. above the upper boards, and so have to sustain the pipe, grasping it by the thick end of the conical mouth. Only the extreme tip enters the upper board. All holes are best scorched with a hot iron after being bored.

When the holes are bored, the interiors of the channels are well smeared with thin glue to close any flaw which may have been started in the process of boring. The sliders and boxes in which they work are best burnished with blacklead, and pins should be set in the slider cases to ensure the slider only moving its proper amount.

The Wind Chest. The wind chest is a shallow box, about 4 in. deep, or more, according to the size of the organ, attached to the under side of the soundboard. It is directly connected with the bellows by means of the wind trunk, a large wooden tube. This box contains the mechanism by which the wind is admitted to any of the channels in the soundboard, and thence to any pipe, for it will be remembered that there is one channel to each of the fifty-four notes of the keyboard, as well as one channel in the pedal soundboard for each of the pedal notes.

The width of the wind chest is governed by the length of the pallets which are to cover a great portion of the soundboard channels enclosed therein. The pallets are the wooden doors, with leather hinges which close the channels normally, and which are pulled downwards when a note is pressed. The back of the wind chest is usually made of a very stout bar of timber, called the wind bar, which helps to support the soundboard and enables it to bear the weight of the pipes.

The Pallets. To each channel is fitted a pallet, freely movable, but capable of firmly closing the portion it is destined to cover. It is kept closed normally by a wire spring, one end of which bears on a bar running the whole length of the wind chest, and the other on the surface of the pallet. The face of each pallet is covered with leather to ensure better closing of the aperture, and a ring or hook is attached to each which eventually is connected with the action of the organ. These rings are placed 1½ in. from the end of each pallet.

The bottom of the wind chest has to be bored at a number of spots exactly under the pallet rings and through the holes wires, known as *pull-downs*, have to pass to open the pallets, but at the same time the wind must not be allowed to escape through these borings. This is effected by fastening a piece of brass on the inside of the bottom board of the wind chest, with holes in it exactly of the size to take the pull-down wires; and along the edges of this brass slips of wood are glued to prevent any wind escaping beneath it. The pull-down wires are then passed through the board and the brass plate, and the ends attached to the pallet rings. The pull-downs must work very smoothly and never stick. All this being arranged, the open portions of the channels on the soundboard which are not covered by the pallets are covered in by gluing sheepskin or parchment over them, making an air-tight joint. The front board of the wind chest is made removable, to enable the pallets to be got at if necessary, but its joints must be made perfectly air-tight.

The bellows are not difficult to make. The form consists of three main boards for each bellows—the middle, top and feeder, as they are termed. There are also a number of thin plates of wood, known as ribs, to strengthen the sides. The whole are united by gussets of skin, and by leather hinges. The feeder must have ample room for play, according to the size of the organ, varying from 10 in. to nearly 2 ft. The upper part of the bellows, or reservoir, must also have the same amount of play, or possibly a little more. The middle board must be a little longer than the other two, so that its ends may rest upon the frame of the organ. It is the immovable base upon which the bellows work.

The middle board has a shallow box, some 4 in. deep, or more, affixed to its upper surface, or the same size as the top board. This is to enable the wind trunk to be attached to the reservoir, and is called the trunk band. In the reservoir there are sixteen ribs, and in the feeder only six, and of these last the long ribs are triangular in shape. The reservoir is made in two stages, the ribs being carried on a light frame the same size as the top board, and the folds are therefore double.

Valves. An opening is cut in the feeder board for the admission of external air, and in the middle board for the transfer of this air to the reservoir. Little bars are fixed across these openings, converting them into gratings, and valves, or "clacks," of white leather are attached thereto. The valves are best made of two thicknesses of leather glued together, and fastened at the edge by a slip of wood and a few brads, thus being firmly held down to the boards. They should fly open at the slightest pressure, and close quite flat. A valve 4 in. square should be made in the top board, opening inwards, and held closed by a stout spring to prevent over-blowing. This is opened by coming in contact with an iron rod when the reservoir is over-distended.

The wind trunks are rectangular wooden tubes, with the joints covered with leather to stop all leaks.

The Action. The essentials of an organ action can best be learnt from the accompanying diagram [4]; but it must be remembered that in nearly every organ various additions have to be made to these plain essentials on account of distance of soundboards from keys, and so forth, for it must be recollected that in an organ with more than one manual, however the pipes may be arranged, each manual *must* have its own perfect action mechanism.

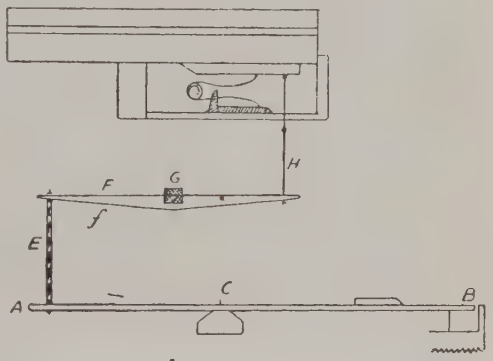
AB is the keyboard, balanced on a pin rail near its centre, and has a pin, C, passing through a little mortise. Another pin keeps it in its place. E is a sticker, or light rod, which pushes, having wires at each end by which it is connected to AB at one end and to F, a backfall, or lever, at the other. F works on G, a backfall bridge. The other end of F, opposite to the sticker, is attached to H, the pull down, which is seen passing into the wind chest, and fixed to the pallet. This is the bare outline of the simplest possible action.

The necessary transference of motion in organ actions often necessitates the employment of rods which pull, which are then called *trackers*, and also of levers of angular form, turning between pins. These in their simplest form consist of rollers with arms projecting from them, and are called *rollers*, the frame in which they are fixed being known as *roller board*.

The mechanism of the stops varies as much as that of the keys, and depends upon the position of the slider which has to be drawn. It resolves itself into a series of expedients for transferring the pull at the organ bench to a pull or push, as the case may be, at any given spot, and in this transference use is made of roller boards, trackers, and stickers. Only a little ingenuity is necessary to work out a scheme for any particular stop in any given position.

The pedal action is only a strong copy of the manual action, and calls for no special comment.

Voicing and Tuning the Pipes. The voicing of pipes is the highest branch of the organ-builder's craft, and cannot be taught save by practical instruction and by experience born of spoiling many valuable pipes. The slightest touch on the lips of a pipe may entirely alter its character. The tuning of organ pipes is difficult, but not so difficult as voicing. The tops of open pipes are cut down, a strip being taken out of the side till the right pitch is arrived at. Stopped pipes have their stoppers pushed in or pulled out till the desired result is attained, while reeds have the steel or brass rod which controls the reed knocked in or out to flatten or raise the pitch. It may be mentioned that two persons at least are necessary to tune an organ, one to manage the keys and the other to undertake the actual alteration of the pipes.



4. ORGAN ACTION

[For explanation, see text]

Reed Organs. Reed organs have bellows of two classes. In American organs the wind is drawn through the tongued reeds into the bellows and so discharged into the air; in harmoniums the wind is forced through the reeds from a wind chest filled by the bellows from a reservoir, as in the case of an organ. The making of the bellows in both only differs in the position of the valves, the one having the feeder with its valve to take air from the reservoir and deliver it outside, while the other has its valves in the reverse position. The spring which governs the reservoir is also reversed.

The reeds themselves in an American organ are in a frame from which they can be drawn by means of a hook. They are tuned by scraping them—at the point to raise the pitch and at the base to flatten it. Their voicing is accomplished by giving them a slight curvature. Harmonium reeds are fixed at the bottom of wind tubes leading from the wind chest, which rests on the top of the reservoir, to the pallets. They are screwed down. Their tuning is accomplished in the same manner as that of American organs, but they do not lend themselves to such varieties of voicing, the peculiar qualities of tone being obtained by variations in the wind tubes, which receive the vibrating column of air.

MUSIC CONCLUDED—END OF GROUP 17

THE TEA PLANTATIONS OF THE EAST

PICKING TEA NEAR KYOTO

SORTING LEAVES IN CEYLON

SOLDERING DOWN PACKETS OF TEA FOR EXPORT AT COLOMBO

Cultivating Indian and China Teas. Tannin. Coffee Growing and Manufacture. Chicory. Cocoa and Chocolate. Mineral Water Manufacture.

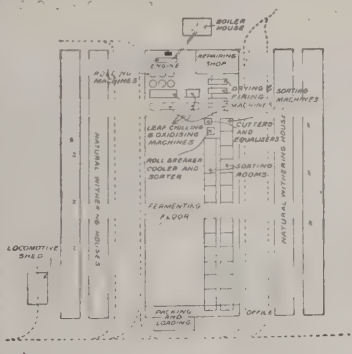
BEVERAGES

TEA is an infusion of the prepared leaves of the tea plant, the species usually employed being the *Thea chinensis* and *Thea assamica*. It was first met with in China, where it is said to have been used four centuries B.C. It was, however, a very common article in the eighth century A.D. Its introduction to Europe dates from the beginning of the seventeenth century, and the import into this country had grown into considerable magnitude by the middle of the eighteenth century, when it became quite a general beverage.

The tea plant is a native of China, and was introduced into India in 1850, but as now grown in India it is generally a hybrid with Chinese varieties.

Tea, as it is put on the market, may be divided into two classes, the green and black teas. This distinction is based solely on the method of manufacture, and is not due, as originally supposed, to a difference in the tree from which the leaves are derived. Both green and black teas are produced in China, Japan, Assam, and Ceylon, although it is usually admitted that the best green teas are made in China [see also pages 5304 and 5306].

Cultivating the Tea Shrub. The cultivated plant is a bushy shrub, not exceeding 6 ft. in height, and somewhat resembling a Portugal laurel. The leaves should not be plucked when the trees are too young, otherwise, when they come to maturity, the yield is much impaired. The plan usually adopted is to pluck the leaves when the plant is three years old; the yield will then be about 80 lb. of tea per acre. The best yields will be obtained from trees which are six or seven years old, when the yield will amount to 320 lb. per acre, although maximum yields, amounting to 800 lb., have been obtained in India. After the eighth year it is preferable to replant. The seeds are usually gathered in October, about a year after the flower has faded, and are then kept in sand and earth until the following March. By this time the seeds will have germinated, and are ready for planting out. Old trees are removed every year and replaced by seedlings. In selecting the ground, attention should be given to thorough drainage and irrigation, for which purpose a good supply of water is necessary. In general, hilly districts are best adapted for the purpose, and the soil should be a rich loam.



1. PLAN OF INDIAN TEA-HOUSE

Gathering the Crops. Whether for green or black tea, the leaves are plucked three or four times a year, those first plucked producing the best tea. The crops are classed according to the age of the leaf, and designated according to their source. Some of the more important are Hyson, Pekoe, Souchong and Congou. Hyson is a term applied in China to the leaf-buds and the first leaves picked in April and made into green tea. Other green varieties are known as "gunpowder," Tankay, and Imperial. Of the black varieties, Pekoe represents the youngest leaf and leaf-buds gathered in April. Sometimes it is flavoured by the addition of orange and other flowers, when it goes by the name of "Orange Pekoe." The same term is applied in Assam as in China. The term "Flowery Pekoe" is also applied to this class. Souchong is plucked next, and is followed by Congou.

Chinese Methods. The manufacture of green tea differs from that of black tea in that it is prepared as quickly as possible from the freshly-plucked leaves, without allowing any fermenting processes to set in. On the other hand, with black tea a certain amount of fermentation is encouraged. The processes employed vary somewhat in different countries, but in the case of green tea they do not differ so much. The leaves gathered in the morning are treated the same day. The first process consists in steaming, with subsequent drying, although in India the steaming process is usually omitted. When dry, the leaves are roasted—that is to say, they are heated in pans over the fire, stirring continuously. The temperature should not rise above 160° F., and the process lasts about five to seven minutes. The leaves, now in a soft, pulpy state, are rolled to break the cells and liberate the aroma; the rolling operation is followed by drying in the sun; and these processes are repeated three times in succession, and then followed by another roasting, after which they are sifted and sorted, and finally roasted again, although the order of the last two operations may be reversed.

In the case of black tea, after drying in the sun and rolling, which may be accomplished either by hand or in the rolling machine, the leaves, in the form of balls, are left to ferment. This process must be put an end to at the right moment in order to obtain the best result, and it is effected by breaking up the balls and spreading the leaves in the sun to dry. This is followed by firing, the leaves being spread on trays with gauze bottoms, heated from underneath by fire or hot air; after firing, the leaves are ready for the market.

Tea Cultivation in India and Ceylon. As by far the greater proportion of tea imported into this country comes from India and Ceylon, we shall describe the methods there employed for cultivation and manufacture.

In March the young shoot, with fresh leaves, or the first "flush," is ready for gathering. This consists of a shoot or new growth bearing the bud and five or six leaves. The pluckers gather the bud with one, two, or three leaves, according to the quantity desired. The buds yield the finest tea, known as "golden or silver tip." The top leaf

produces Orange Pekoe, or, when large, "Pekoe." The second or lower leaf also yields Pekoe, but, when large, Pekoe Souchong (Christison).

The pluckers go round the gardens at intervals of about a week. It is very important that they should avoid gathering leaves which are too coarse, or unripe shoots. The baskets with the leaves are returned as quickly as possible to the tea-house.

Manufacturing Operations. These are as follows [see illustration **1**, showing plan of an Indian tea-house]: (1) Withering or limping; (2) rolling or curling; (3) drying or firing: (4) separating or sorting and cutting or equalising; (5) final firing; (6) packing for export. These operations take together some 22 hours to 26 hours. The withering is carried out in houses built open at the sides, fitted with layers of trays or racks. The object of withering is to remove 20 per cent. to 50 per cent. of the water, so that when subjected to the next operation, the rolling, the leaf is sufficiently tenacious to stand this somewhat rough treatment. The leaves are now taken to the rolling machines. These are of special construction, and give to the leaves the necessary twist, at the same time rolling them into balls. The balls are then broken down.

The next process consists in spreading out the withered leaves on the concrete floor of a large chamber. The chamber is kept dark, and the leaves are covered with cloth or muslin saturated with cold water. In the course of from two to eight hours the so-called fermentation process is complete.

They then pass to cooling and oxidising machines, in which they are spread out on wire-gauze covered tables, through which a current of air is drawn.

Methods of Firing. They are now taken to the tea drying and firing machines. In large factories this is best accomplished in three stages. In the first stage the leaf is passed quickly through an automatic machine which immediately checks the fermentation by exposing the leaves to a temperature of 300° F. The effect of this is to turn them darker in colour, and they leave the machine half dried. The second is a similar automatic drying machine, the temperature of which is 200° F., and on leaving this machine the leaves are almost dry. The third stage is accomplished in a machine under control, so that the operation may be carefully watched. The object of the process is to drive off the moisture as completely as possible without losing the essential oils.

2. COCOA-ROASTING MACHINE

The roasted leaves are next picked over by hand and then passed through a mechanical sorting machine to remove foreign matter, stones, dust, etc. The leaves then pass to circular or revolving sieves fitted with wire of different mesh, so as to separate the leaves into two or three qualities. The general principle of the machine is similar to one which has been already described [see MILLING, page 5273]. The different products are now subjected to a final firing to remove any residue of moisture, after which they are ready for packing.

Chemistry of Tea. The aroma of tea is due to small quantities of volatile oil not exceeding ½ per cent. of the weight of the tea. The peculiar physiological action is due to a substance formerly termed "theine," but now known as "caffeine," as it has been found to be identical chemically with the alkaloid obtained from coffee. Teas also contain a considerable quantity of tannin, averaging from 10 per cent. to 20 per cent. The public analyst is not often called upon to examine teas, as all that is imported into this country is examined by the Customs authorities, and rejected if found to be adulterated.

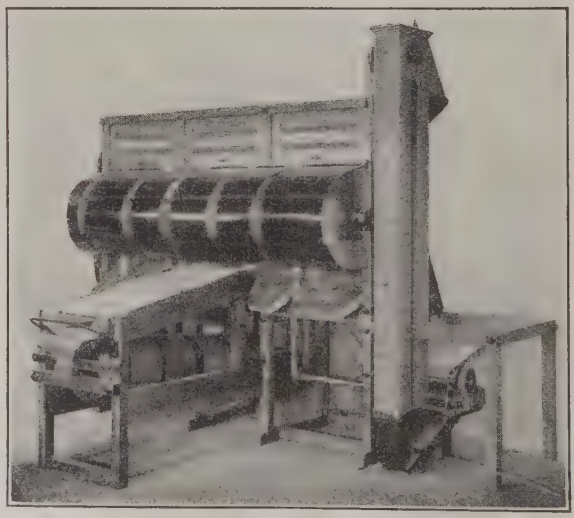
CONSTITUENTS OF TEA-LEAVES

Constituents.	Original leaves dried.	Same made into green.	Same made into black.
Crude proteins ..	37·33	37·43	38·30
Crude fibre ..	10·44	10·06	10·07
Theine (caffeine) ..	3·304	3·200	3·300
Tannin	12·91	10·64	4·89
Hot-water extract	50·97	53·74	47·23
Ash	4·97	4·92	4·93

The proportions of essential oil, caffeine, and tannin vary considerably, and there is also a distinction between the quantities in green and black teas.

A great number of analyses have been made on tea by different authorities. The table given above, obtained by a Japanese chemist, will give some idea of the effect of constituents on the original leaves when converted into green and black tea.

In the above figures it will be seen that the constituent most affected by the process of manufacture

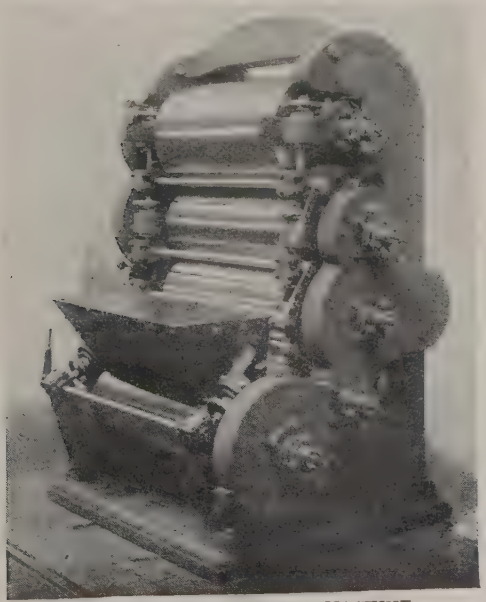


3. COCOA-NIBBING, HUSKING, WINNOWING AND GERM-EXTRACTING MACHINE

is tannin, of which the green tea contains more than twice as much as the black, from the same leaves.

Coffee. Coffee consists of the roasted seed contained in the fruit of the coffee tree (*Caffea arabica*). A number of species and varieties have been discovered, three of which are now cultivated: (1) The Arabian or Mocha coffee, which differs from the others in that it usually contains only one seed in each berry; (2) Jamaica coffee, which has usually two seeds in the berry; and (3) East India or Bengal coffee, characterised by its small berries. The cultivated plant is usually about 6 ft. high, and would grow much higher, but its height is kept down by pruning. It is grown in various parts of the world, generally at some height above the sea-level. It is cultivated in the West Indies, Mexico and Central America, Brazil and various parts of Africa, Arabia, India, Ceylon, and parts of the East Indies, but it is chiefly grown in Brazil. The fruit has been likened to a small black cherry and consists of sweet pulpy matter surrounding one or two seeds, which seeds are themselves enclosed in a thin tough membrane termed the parchment.

Manufacturing Operations. The fruit is allowed to ferment to help the removal of the outer pulp, and the parchment is got rid of by passing the seeds between rollers and winnowing out the husk. The bean is yellowish in colour, and has to undergo a process of roasting to fit it for consumption. The roasting effects two objects—it brings about important chemical changes which develop the flavour; and at the same time the raw bean, which is tough, is rendered brittle, so that it can be more easily ground. The process of roasting requires care; under-roasted beans yield an infusion with a raw flavour, whereas if too strongly heated they are burnt. Usually some sort of rotary apparatus is adopted by which the beans are kept in motion and uniformly heated [see also Roasting Cocoa]. The temperature should not rise above 450°F., and the beans should lose about 18 per cent. of their weight when roasted to a chestnut brown colour.



5. CHOCOLATE-REFINING MACHINE

4. COCOA-GRINDING MILL

The most important constituents of coffee are the volatile oil, to which its fragrance is due, and the alkaloid caffeine which has already been described under Tea. The oil was isolated by Bernheimer from the distillate obtained by heating coffee beans. It is an oil boiling at 195° to 197° C., and has been termed "caffeol."

Coffee is frequently adulterated, and while the substitute generally used is chicory, many other substances have also been employed, including—according to Pearmain and Moor—dandelion root, mangel-wurzel, turnips, beans, peas, flour, and condemned sea biscuit more or less caramelised by baking, and burnt sugar. In addition to this, a patent has been taken out for the manufacture of artificial beans from chicory and other adulterants. Anyone familiar with the bean would have no difficulty in detecting the imitation article, although they are not met with much in this country, it being more profitable to adulterate the ready-ground coffee. On chemical analysis coffee contains about 1½ per cent. of caffeine, 12 per cent. to 20 per cent. of fat, 30 per cent. to 37 per cent. of cellulose, and about 4 per cent. of ash.

Cocoa. Cocoa, sometimes spelt "cacao," is made from the seeds of the *Theobroma cacao*, a tree of some size which grows in the West Indies, Brazil, Central America, and other parts. The fruit is elongated in shape and consists of five compartments containing a sweet pulp in which the seeds or beans are embedded [6]. The fruit is split in two and the beans separated from the surrounding pulp and spread out to dry on bamboo floors exposed to the sun. To rid them of a certain amount of adhering pulp, and also to improve the flavour, they are submitted to fermentation. For this purpose they are placed in wooden barrels, covered over with leaves, and left a day or two. The process is complete when the colour has changed from red to chocolate. The beans are then taken and washed to remove the adhering portion of pulp, and after drying are ready for export. The cocoa seeds or

6. CACAO FRUIT

beans are the raw material for the manufacture of chocolate, cocoa, and various sweetmeats.

Manufacturing Chocolate. The manufacture of chocolate comprises the following operations (Zipperer): (1) Storing, cleansing, and sorting; (2) roasting; (3) crushing, shelling, and removing radicles; (4) mixing the different kinds of beans; (5) grinding the beans until they yield a homogeneous pasty mass when warmed; (6) the incorporation of sugar and spices with the liquefied cocoa mass; (7) trituration by rollers; (8) extraction of air and division and moulding; (9) cooling the finished chocolate.

In general chocolate may be defined as a mixture of pure cocoa (free from shell or germ) and sugar, with the addition of cocoa butter, spices, vanilla, or other flavouring as required.

The beans are first cleaned or roughly sifted, so that the dirt and flat beans are separated out. A cocoa-bean cleaning machine may be used, and the clean beans are delivered on to a travelling web, and any stones or foreign substances which have passed the machine, being about the same size or larger than the beans, are picked out by hand.

Roasting Cocoa-beans. The picked beans are next roasted for the purpose of developing the aroma, gelatinising the starch granules, and rendering the husk or shell brittle so that it is more readily removed; at the same time the astringency is largely got rid of. The plant usually employed consists of a roasting drum similar to that used for coffee, but the temperature required is lower, and should not exceed 130° C. to 140° C.

The illustration [2] represents a gas cocoa-roaster. The revolving drum is heated externally, and the gas is mixed with heated air to render the combustion more complete. The beans are fed through the hopper at the end, and the inside of the drum is fitted with helical blades to ensure the beans being turned over and fed constantly to the centre. The heated gases and steam from the beans escape through the hollow shaft of the trunnion of the bearing.

Separation of Husk and Germ. After roasting, the beans are delivered into a cooler below, the bottom of which is provided with a perforated plate so that air can be drawn through the beans by means of a fan. When sufficiently cooled, the beans are treated to separate the husk or shell and germ from the particles of kernel. For this purpose they are crushed, keeping the pieces of shell as large as possible as this facilitates subsequent separation. The cocoa nibbing, husking, winnowing, and germ-extracting machine is shown in **3**. At the bottom of the hopper is a "nibber," with two pairs of rollers (seen on the right-hand side of the figure) to crack the beans, which are then taken up by the elevator and delivered into a revolving drum made up of six different sections of perforated metal, each of which is somewhat coarser than the last. Each section is provided with a fan which blows away the particles of shell, leaving the clean cocoa-nibs to fall upon inclined sheets fitted to each section. As a small amount of nib may be carried over with the shell, an intermediate chamber is provided, into which it falls, most of the lighter husk being carried beyond. This chamber is fitted with a worm so that the mixture of nib and shell is returned to the hopper for treatment over again. About the centre of the drum the perforations are of such a size that medium sized nibs and germ pass through together. They are conducted to inclined sieves and a perforated drum, by means of which the germ is removed much in the same way as cockle is taken out of wheat [see MILLING, page 5274]. Here it is the particles of kernel lodge in the hollows of the walls of the cylinder, while the germ passes off as tailings.

Grinding and Refining Machines. For whatever purpose the cocoa is required it is essential that it should be finely ground. For this purpose the French form of mill, consisting of two stones, a bed-stone and a runner on a vertical axis, is usually employed. The action of this form of mill has been described in PAINTS AND POLISHES [page 4927]. Figure **4** shows a five-stone cocoa-grinding mill.

The cocoa, which is fed into the middle, leaves the stones in a semi-liquid condition. The ground cocoa is not heated until it is liquid, when it is transferred to a melangeur or to a mixing and kneading machine, where the necessary sugar and spices are added.

The stiff paste is then passed through chocolate refiners. These are built either with inclined rolls or are upright machines with rolls superimposed. A five-roll (chilled iron) vertical chocolate-refiner is shown in **5**. The refining process reduces the chocolate to a smooth condition; it is then usually stored in blocks for some time in a dry room. Illustrations **2** to **5**, and **7** are from photographs of machines by Messrs. Joseph Baker & Sons, Ltd.

For conversion into tablets it is mixed or kneaded as required and passed through a weighing machine, which also compresses it and extracts any air, and thence to moulds. For certain kinds of chocolate, especially if larger quantities of sugar are added, an addition of cocoa butter is made; but for some cheap ordinary chocolate this is replaced by a cheaper vegetable butter such as coco-nut fat, and the outer shell or husk of the bean, representing 20 per cent. by weight of the whole, is also ground up and utilised. Milk chocolate contains a large proportion of concentrated milk, and a smaller proportion of cocoa.

Cocoa Powder. For use as the beverage commonly known as cocoa or "soluble" cocoa, the preliminary processes are carried out as we have already described; but at some stage the material is treated with weak alkalies, such as carbonate of soda, potash, or ammonia, and heated, the effect of which is to modify the cellular matter or saponify part of the cocoa butter in such a manner that, on mixing with hot water, the cocoa remains suspended instead of settling at once (so-called Dutch process).

Some English manufacturers, however, do not use alkali and yet are able to obtain a cocoa quite as soluble as with the Dutch process, but perhaps somewhat lighter in colour, the effect of the alkali being to darken the cocoa when in the cup. French makers are not allowed to use alkali. It is also necessary to remove a large proportion of the oily or fatty matter contained in cocoa—namely, the cocoa butter. This is carried out after roasting by hydraulic presses. Altogether the cocoa butter forms about half the weight of the seed. It is a white solid fat which melts at the low temperature of 30° C., a little below the normal temperature of the body.

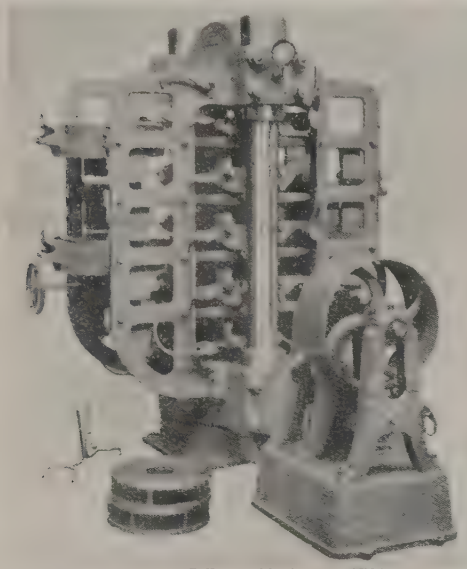
Cocoa contains an alkaloid, theobromine, which is a characteristic and important constituent. It is chemically closely allied to caffeine, but its physiological action is stronger. The amount of theobromine is usually about 1½ per cent.

MINERAL WATERS

Mineral waters may be divided into two classes—natural and artificial. The natural waters are taken from some spring or other source of supply, and consumed on the spot or bottled for delivery direct to various countries. Artificial waters are

prepared by the addition of saline substances and impregnations with carbonic acid gas.

There are also waters which stand midway between these two classes—those which already contain some salts or other dissolved substances



7. HYDRAULIC COCOA-BUTTER PRESS

having medicinal or other qualities, and which are fortified by the addition of further salts or carbonic acid gas.

Principles of Manufacture. Water such as is got by artesian wells from the chalk below the greensand formation in the London Basin is perhaps the best adapted for the manufacture of "minerals." It is soft, slightly alkaline, and very free from organic impuries. The analysis of such a London water made by a well-known expert showed only 0·0004 parts per 100,000 of organic ammonia, 5° of hardness, and six bacteria per cubic centimetre. Such water is practically sterile.

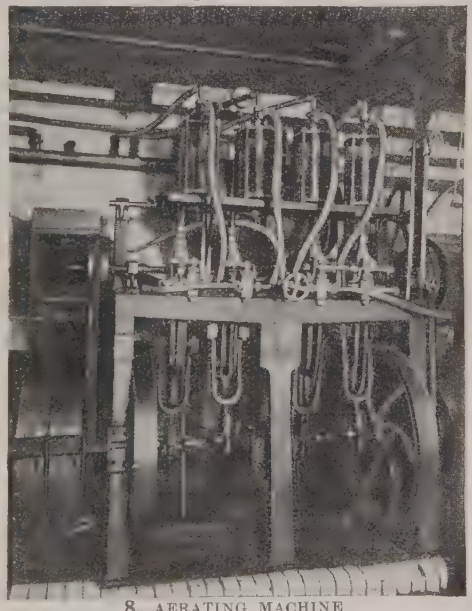
Aeration, as it is called, consists in saturating water under pressure with carbonic acid gas. Water at ordinary temperature, say 60° F., absorbs about its own weight of this gas (if cold, it absorbs more; if warm, less). All bottling is done at ordinary temperatures with cold water. If the pressure on the gas be doubled, the volume is approximately halved; if doubled again, the volume is again halved; but, no matter what the pressure, one pint of cold water (60° F.) absorbs one pint of the gas. If, then, we double the atmospheric pressure by applying 15 lb. per square inch, we get twice the amount of gas into the water. On releasing the pressure, the excess of gas escapes into the air. As ordinary bottling is done at from 60 lb. to 100 lb. per square inch, a large amount of the gas is absorbed by the liquid.

The principles of manufacture, which we will describe in some detail, are chiefly in accordance with those adopted by Camwal, Limited, where the work is conducted under scientific supervision.

Mixing the Gas. The carbonic acid gas used in these works is a natural gas, and is received compressed as a liquid in steel cylinders under a pressure of 800 lb. per square inch. These cylinders are stood on end, and connected up, six at a time, with a receiver resembling a miniature gas-holder. By discharging into this holder, the gas is obtained under a few inches of water pressure. The rate of evaporation from the cylinder causes a portion of the liquid to freeze to a solid, which makes itself evident by frost on the outside. The cylinders are then removed and others attached. The warmth of the air, or of warm water, converts the solid gas back into a liquid, and the cylinders are again placed in contact with the receiver, and the gas completely absorbed by the aid of a warm water-jacket.

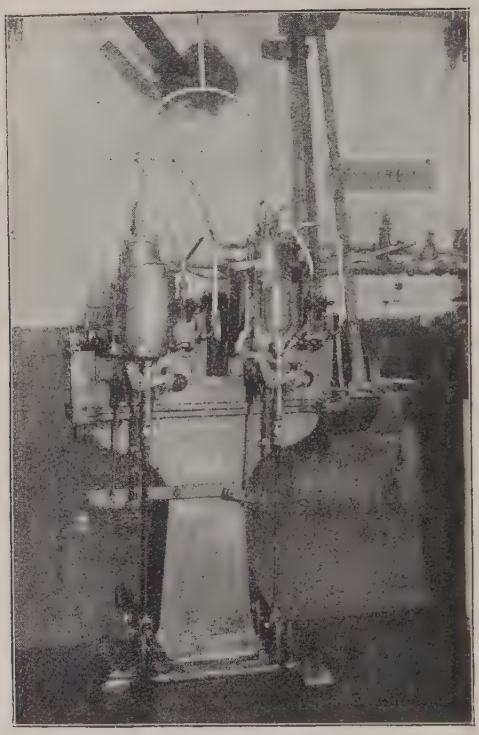
The gas from the receiver then passes through pipes to the aerating machine. Here it is washed as a final precaution, by bubbling through glass cylinders containing water. As the gas contains 99·4 per cent. of pure carbon dioxide, this precaution does not appear to be necessary. The gas then passes through three-way cocks, where it meets with water. These cocks can be so regulated as to supply any proportion of water and carbonic acid gas. The water, the composition of which has already been referred to, is pumped from the deep well into a tank, where, for the manufacture of soda-water, it is rendered alkaline by the addition of pure carbonate of soda. The water has a natural temperature of 56° F. Each mixing tank holds exactly 200 gallons. Bicarbonate of soda is added by means of a suspended filtering-bag, through which the water flows and dissolves it into the tank. The chemist checks every mixing by analysis, as a check to the weighings, the figures of which are carefully recorded.

The alkaline water then passes through silver-plated connections and tin pipes to the various aerating machines above described. It first enters a small feed tank with a glass front, provided with a ball-cock, and then goes to the three-way taps, whence the mixture of gas and water passes into the carbonating chamber. The machine is



8. AERATING MACHINE

made of gun-metal, and is lined inside with tin, ¼ in. thick. With a large machine, the cylinder has a capacity of 80 gallons, and is worked under a pressure of 180 lb. per square inch, the cylinder being half full of water and half full of gas.



9. SYPHON-FILLING MACHINE

Agitation is promoted by a longitudinal shaft provided with triangular perforated paddles, and revolving at 60 to 80 revolutions per minute. The gas and water are pumped into the cylinder by four pumps and four sets of pipes, pairs of which can be worked independently [8].

The water which has thus been ærated thence passes to the filling machine at a pressure of about 180 lb. if required for filling syphons, and 120 lb. for filling bottles and "plain goods"—that is, not containing syrup or sugar—and about 90 lb. for sweet drinks. The actual pressure in the syphons or bottles is about half that at which the water is forced into the vessel. The biggest carbonating cylinder will fill about 1,800 30-oz. syphons per hour.

Filling Aerated Water Bottles. In filling bottles fitted with glass marbles as stoppers the marble is forced into the neck of the bottle by the pressure of the gas inside the bottle.

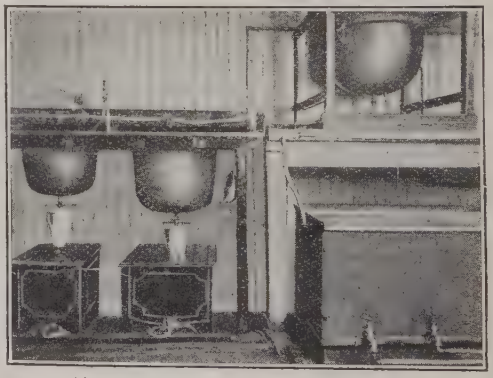
With screw-stoppered bottles, the stopper is screwed loosely into the neck of the empty bottle; it is then placed under the machine, which removes the stopper, fills the bottle, and screws the stopper in firmly.

Bottles fitted with ordinary corks are held in position by the machine and the cork is placed in a holder. When the machine is started working, the bottle is filled, the cork dropped into position, and rammed into the neck by means of a small ram. By the thrust of an arm, the bottle is thrown out of position and pushed down a chute. To avoid "cork dust," the corks are previously washed in water, but as an extra precaution, the ram delivers a spray of aerated water, so as to further cleanse the cork at the moment of insertion. In all the machines, the aerated water is forced into bottles by the pressure of the carbonating cylinder. If syrup is to be added, as in the case of lemonade, ginger ale, etc., it is admitted to small pumps from the tanks above, which deliver at each stroke the requisite quantity to the bottle, which is made up at the same time with the proper proportion of aerated water. All the modern filling machines are fitted with a syrup and aerated water saving device. By this means, no water or syrup can flow unless the bottle to be filled is fixed in its place. In this way, a great deal of unnecessary waste is saved.

When the aerated water is forced into the bottles the air in the bottle is driven out. This is called "snift'ng." In the case of syphons, the "snift'ng" gases are collected and used again, as they consist of pure carbon dioxide left from the last filling, but in the case of bottles they are allowed to escape, as they contain a large percentage of ordinary air.

Syphons. Syphons are filled through the spout. They are fixed so that the spout is pressed against the pipe through which the water is to be admitted. The lever is then pressed down, by means of a small arm actuated by means of a pedal, and the soda-water is forced in so that the pressure in the syphon is equal to that at which the water is entering. The water valve is then closed automatically, and the "snift" valve is opened to allow the gas inside to escape. The "snift" valve then closes again, the water valve is opened, and the syphon is filled up [9]. The gas in the best soda-water syphon contains about 0·6 per cent. of air, the rest carbonic acid. There must not be more than 2 per cent. of air, or the syphon cannot be properly emptied. After the syphons have been filled the tops are burnished by means of a revolving calico disc, and then the body of the syphon is washed and the labels stuck on. The syphon tops of the Camwal Co. are made of pure tin, with only sufficient antimony and bismuth to give the requisite hardness. Some are silver-plated, but this is merely to give them a better appearance, as the tin is absolutely safe.

There are two sorts of syphon tops—*viz.*, those with the long lever, and those with the short ones [11]. With the long lever tops, the lever is raised to deliver the liquid, while with the short valve, the valve is depressed. The former work against a spring, which must be strong enough to prevent leakage; but in the latter, the pressure forces the valve against its rubber setting, and so makes its own joint. Opinions differ as to which is the better, but the public seem to like the long lever, as it gives better control when pressing. The sudden spirt when starting a new syphon is due to the valve sticking and coming away suddenly. The Idris



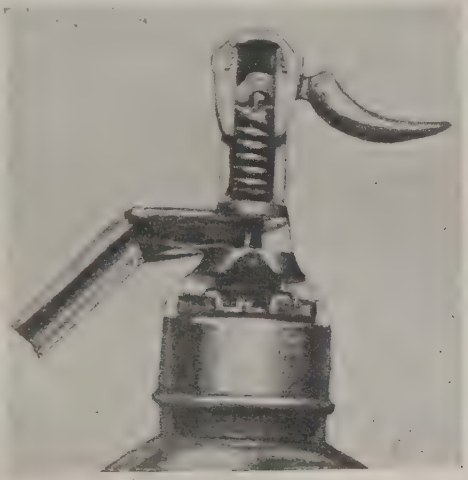
10. SYRUP COOLERS AND FILTERS

Company make a china plug and nozzle fitted inside, so that none of the liquid comes in contact with the metal top. Metal contamination results from the use of unsuitable metal tops.

The Preparation of Syrups. The best crystallised cane sugar is boiled in a steam-jacketed copper. The strength of the syrup is made up to from 40° to 50° Tw., 2 cwt. of sugar being used at each boiling. The syrup is then run into a cooler [10], and fruit acid essences are added to give it the necessary flavours. The mixture is then filtered through a bag to the tank, whence it is led to the various filling machines.

Soda-water varies in strength between 5 gr. and 30 gr. of bicarbonate per pint. The British Pharmacopœia formerly gave soda-water at 30 gr. per pint. Prosecutions are usually instituted where the amount is under 5 gr. per pint. The strength is largely a matter of taste. The amount in the case of lithia is 10 gr., according to the British Pharmacopœia, 1914. Potash is 5 gr. to 15 gr Seltzer water, properly prepared, is a mixture of sodium bicarbonate, sodium chloride, and magnesia, but, as generally sold, means nothing. There are, in addition, aerated distilled water and carbonated water.

Preparation of Ginger-beer. The water is first boiled in a steam-jacketed copper, and is then passed into a mash-tun, where it is mixed with crushed Jamaica ginger. The whole is then run into a settling tank where fruit acids are added, and the liquid, after reduction to proper temperature, is drawn off into the fermenting vat, where it is mixed with sugar (1 lb. per gallon), and allowed to ferment for twelve hours. It is then run off and filled into stone bottles in special filling machines, after which it is stored for about a fortnight, during which time the proper aeration is promoted as a result of the fermentation which takes place. Ginger-beer so prepared contains from 0·6 per cent. to 1·4 per cent. of alcohol. The extreme legal limit is 3 per cent., but manufacturers are warned if 2 per cent. is exceeded.



11. CAMWAL SYPHON TOP

Preparation of Carbonic Acid Gas. Many firms still make their own carbonic acid gas by adding sulphuric acid to whiting or sodium bicarbonate. To a large cylindrical tank, half full of water, a charge of 2 cwt. of bicarbonate is added. Sulphuric acid is then run into it from a reservoir situated at the top, and carbonic acid gas, so called, is drawn off by a pump to the aerating machine. On its passage it is purified free from nitrates by passing through alkaline potassium permanganate solution, which also removes any spray of sulphuric acid which might be carried over mechanically. This method of producing carbon dioxide gives trouble on account of the amount of air it is liable to contain, hence the use of pure natural gas.

Large quantities of sulphuric acid, in jars, surrounded with whiting, are shipped to India and the Colonies for the production of carbon dioxide to be used in the manufacture of aerated waters. If these jars should break during shipment the acid is absorbed by merely converting the whiting into plaster of Paris. The empty jars are cleansed, refilled with Indian pickles, and shipped back to this country. Carbon dioxide is also produced during the process of fermentation in breweries, where it is compressed into cylinders and sold to makers of mineral waters.

Perhaps the most advanced method of producing the gas is from coke, according to Stead's and Leslie's patents. A very ingenious process (Stead's patent) has been installed by the Idris Company, whereby gas of the highest degree of purity is produced. The process consists in the main as follows: The products of combustion of special coal or coke are forced, under pressure of 20 lb. to 30 lb. per square inch, into carbonate of potash solution, which is thereby converted into bicarbonate, after which it is heated with the evolution of pure carbon dioxide, and the re-formation of ordinary carbonate.

Domestic and Automatic Aeration. Retailers of mineral waters can now prepare their own if they so choose. Attempts have been made from time to time to introduce a machine for this purpose. From the description already given of the manufacture of "minerals" on a large scale, the principle of the ingenious "multum in parvo" machine known as the "Consol" (Consol Automatic Aerators, Ltd.) will be grasped readily [13].

It enables the retailer to deliver at the point of consumption an aerated water of good quality, freshly made for each customer, and also enables him to dispense with the cumbrous boxes of bottles formerly needed for his business.

This machine occupies a space only slightly exceeding 1 sq. ft., and can be fitted to any bar or shop counter. In addition to ordinary aerated water, it can be made to produce soda, potash, lithia, lemonade, ginger-beer, ginger-ale, etc., by adding the necessary amount of soluble constituents, according to well-known recipes.

It differs from other "draught apparatus," such as soda fountains, various forms of draught arms, etc., in that it manufactures each drink as required, whereas ordinary apparatus has to draw from a previously manufactured store, which deteriorates on keeping. The entire operation is performed by a right and left movement of the handle, which occupies a period of not more than five seconds, so that it is possible to draw on draught the equivalent of 60 dozen bottles per hour.

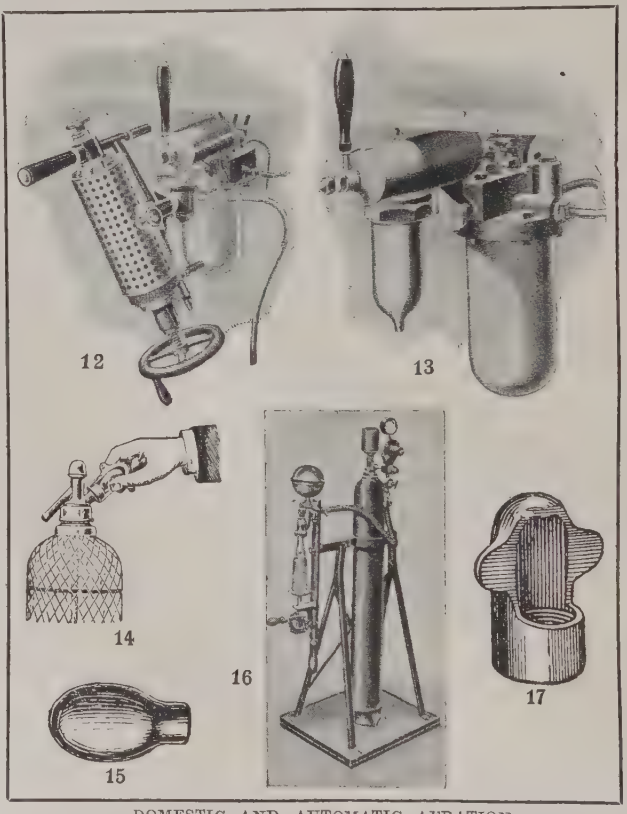
A filter should always be fitted where any doubt exists as to the purity of the water, and in all cases where it is desired to produce the highest class of "minerals." Suitable germ-proof filters have been designed for special use with the aerator, all that is necessary being to introduce the filter at any convenient point in the water supply.

Aerated Water in Open Jugs. It is claimed by some that aeration on a small scale produces a different result to aeration in bulk. It is

said that it so saturates the water with the gas (CO_2), that it is actually held in solution, and not given off in a violent eruption upon the removal of outside pressure. The experiment described below may be taken as showing that water aerated in bulk does *not* retain the gas for any length of time after opening the bottles. We cannot undertake to sift the evidence on this point, and as "minerals" from bottles and syphons, especially the latter, are consumed almost immediately after opening, we need hardly concern ourselves with it. Nevertheless, domestic aeration makes it possible for aerated water to be served in open jugs, without detriment to its sparkling qualities, a point which should prove of decided gain to the public.

The following simple experiment illustrates this. A tumbler of aerated water is drawn from the small hand machine, and a similar tumbler is filled from a bottle or syphon supplied from an ordinary mineral water factory. The two are left side by side for half an hour or longer; each is then gently stirred with a thin rod or knitting needle. That from the bottle will be comparatively flat, whereas that from the small machine will "bead" round the rod and effervesce freely.

Although the aerator has been designed primarily to make and supply aerated water straight into the glass, yet both screw-stoppered and corked bottles can be easily and rapidly filled. Where it is desired to bottle under pressure, an attachment is added for filling any description of bottle, particularly suited for ball-stoppered bottles (known in the trade as cod bottles). This is attached to the aerator by removing the delivery vessel. The illustration [12] shows the attachment.



DOMESTIC AND AUTOMATIC AERATION

12. Consol aerator for bottles 13. Consol aerator for counter supply
14. Sparklet syphon top 15. Sparklet gas bulb 16. Mineral water bottle filler (H. Toomer & Co., Ltd.) 17. Sparklet bulb-holder

Another Simple Machine for Bottling Only. Another machine, worked somewhat differently, is shown in 16. In this case the bottles have first to be filled with the water to be aerated. They are then clamped on to the attachment communicating with a tin ball full of gas under pressure. By pulling up the lever, the bottle is inverted, causing the water to flow into the ball, where, by the aid of shaking, it becomes aerated. The lever is then lowered, so that the bottle is the right way up, when the aerated water finds its way back into the bottle. The machine is of cheaper construction, but slower in its action than the "Consol," and it will not deliver direct into the glass. It appears to answer its purpose.

Sparklet Aeration. We will conclude our account of mineral waters with a short description of the Sparklet syphon (Aerators, Ltd.). By means of this ingenious system anybody can make at any time and in any place as much freshly aerated water as desired. The principle of the system consists in the sale of carbonic acid gas strongly compressed in small steel bulbs which are fitted on to the syphon and pierced by turning a screw, which allows the gas to escape and saturate the water with which the syphon is previously filled. The bulb containing the carbonic acid gas, and the bulb-holder into which it is slipped neck downwards, are shown in 15 and 17. The vase of the syphon, the upper part of which is shown in 14, is filled with water to a red mark near the top, the glass tube is inserted, and the head screwed down without employing undue force. The bulb-holder, containing the bulb, is held with the thumb on the bulb so that the neck of the latter protrudes slightly below the bottom of the holder. The protruding neck of the bulb is now inserted centrally into the hollow formed by a washer and gently screwed down. Inside this hollow and projecting outward is a pin, which enters the end of the bulb and pierces it, in this way admitting the gas from the bulb into the syphon. The bulb-holder is screwed down gradually, shaking the syphon well from time to time and continuing alternate screwing and shaking until no more bubbles of gas are given off. The syphon is now ready for use, but the aeration is improved if the syphon be allowed to stand a few minutes before drawing off the contents.

The glass vases are covered with a metal wire, and are tested to a pressure of 220 lb. per square inch.

Either plain water alone can be aerated or small quantities of soda, potash, lithia, or fruit crystals may be previously added in the form of "sparkloids," thus producing soda, potash, or lithia water, or other effervescing drinks of various descriptions.

CLAYTON BEADLE and H. P. STEVENS

FOOD SUPPLY CONCLUDED—END OF GROUP 18

Petroleum Oil and its By-products. Shale Oil. Uses of Petroleum and its Products.

REFINING PETROLEUM

THE object of the operations which are collectively known as the refining of crude petroleum is to separate the liquid into a series of products best suited for various industrial uses. Crude petroleum as it comes from the well has already been shown to consist chiefly of a mixture of hydrocarbons or chemical compounds of the two elements hydrogen and carbon. These hydrocarbons exhibit a progressive range of boiling points, those at one end of the scale boiling at common temperatures, whilst those at the other end require to be heated to many hundred degrees Fahrenheit before entering into ebullition.

Fractional Distillation. It is, therefore, obvious that if we apply a gradually increasing heat to the crude petroleum we shall successively convert one constituent after another into vapour in the order of their boiling points, and if we pass this vapour through a tube surrounded by cold water we shall cause it to return to the liquid condition. The liquid so obtained may evidently be collected in as many separate portions as we wish, and we have thus the means of dividing and subdividing the crude oil into various products. The process in question is termed *fractional distillation*, and the separated liquids or distillates are called *fractions*.

Stills and Condensers. On the practical working scale the fractional distillation is carried out by the use of a still and a condenser. The still usually consists of a horizontal cylindrical vessel of iron or steel plate, with a dome, like that of a steam boiler, from which a tube or vapour-pipe passes with a slight downward inclination to the condenser. The still is set in brickwork, and is heated by a furnace. The condenser commonly consists of a coil of iron tubing, or a series of straight pipes joined by curved pipes or bends, placed in a tank filled with cold water. The outlet end of the condenser passes into a trough arranged so that the stream of liquid issuing from the condenser may be diverted into various receptacles.

Products. When ordinary crude petroleum is heated in such a still the first commercial product which flows from the condenser is petroleum spirit, or benzine, and this is allowed to flow into the tank provided for it until the temperature of the contents of the still has risen to such a point that distillation of the next commercial product—namely, the petroleum oil or kerosene, for use in lamps—begins. The stream of distillate is then diverted into the kerosene tank until the whole of this product has been obtained.

On further increase of temperature oils of higher boiling point, intermediate in character between the kerosene and the lubricating oils, distil over, and, lastly, lubricating oils of various grades issue from the condenser, these containing the solid paraffin wax if the crude oil undergoing distillation contains this substance, the residue in the still consisting of coke if the distillation is carried to *dryness*, as it is termed.

Usually the process herein described is conducted in two parts, the benzine and kerosene being separated in one still, and the distillation being completed in another still to which the residual oil is transferred. In some districts, and notably in Russia, only a small proportion of the residue which remains after taking off the benzine and kerosene is further distilled, the greater part of the residue being sold as liquid fuel. Where the distillation is carried to dryness, the operation is completed in cast-iron stills, the bottoms of which are of hemispherical form. In the distillation of the lubricating oils it is customary to inject steam into the stills, as this tends to prevent the products being injured by overheating, and facilitates the passage of vapour from the still to the condenser. On the other hand, in the distillation of the kerosene, overheating is often aimed at, the yield being thus increased by what is known as "cracking," which is the conversion of some of the heavier constituents of the crude oil into lighter ones of lower boiling point.

The benzine distillate is re-distilled with the aid of steam, so as to subdivide it into the various commercial products, including motor spirit.

Continuous System of Distillation. The process of fractional distillation which has been described is known as the *intermittent* system, because the still has to be periodically re-charged. In conducting the process of *continuous* distillation, which is the system commonly adopted in Russia, a series of stills is employed. The second of the stills in this series is heated to, and maintained at, a higher temperature than the first, the third to a higher temperature than the second, and so on throughout the series of ten or a dozen, or even more, stills. The crude oil is caused to flow slowly through the whole series, being thus subjected to a gradually increasing heat, while the temperature of the contents of each still remains practically constant. Under these conditions each still continuously yields a product of given boiling point corresponding with the temperature at which it is maintained, and the loss of time, waste of fuel, and injury to plant involved in cooling down and re-heating the stills in the intermittent system are avoided.

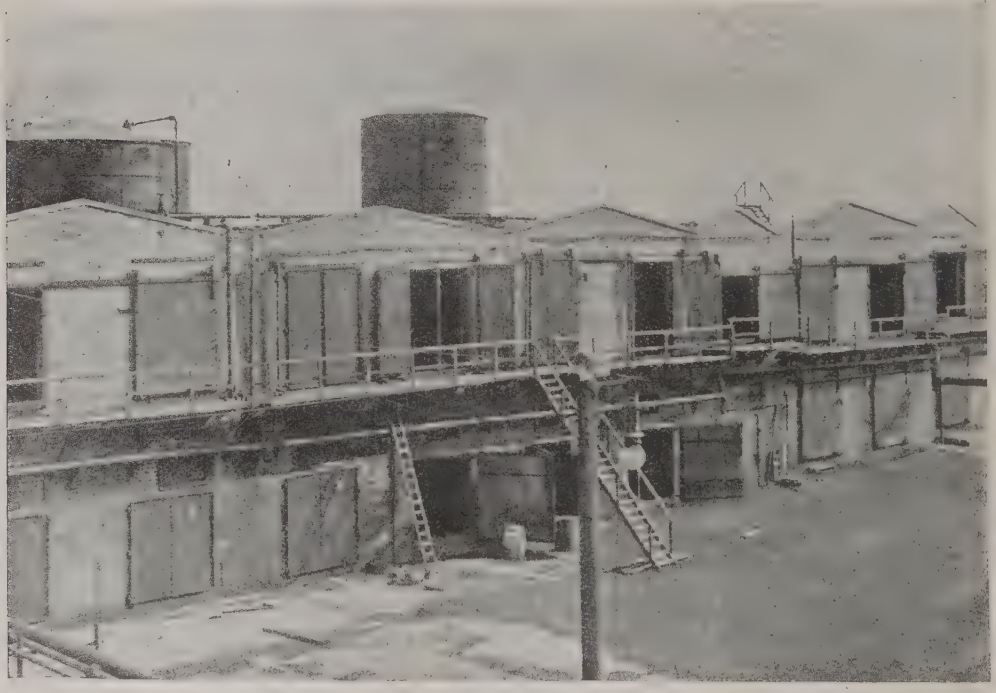
Benzine and Kerosene. The benzine or benzine products and kerosene are purified by agitation successively with sulphuric acid and a solution of caustic soda, followed by washing with water, and when the crude oil contains sulphur a special process is also adopted to remove this impurity from the distillates. The agitation is effected by means of compressed air, the operation being conducted in vertical cylindrical iron vessels termed agitators.

Lubricating Oils and Solid Paraffin. The lubricating oil distillates obtained from crude petroleum containing solid paraffin are artificially cooled to a low temperature, when the paraffin crystallises out and is separated from the oil by means of filter presses and hydraulic presses. The paraffin thus obtained is cast into thin cakes, which are slowly heated in an oven, when the most fusible or readily melted part liquefies and runs

away, carrying impurities with it. The residual wax is then melted up and refined by means of animal charcoal or fullers' earth, being thus rendered colourless and odourless. The separated lubricating oils of various grades are purified in the same manner as the kerosene by treatment with acid and alkali.

Vaseline. This product is obtained by concentrating the residuum of ordinary Pennsylvanian or other similar petroleum to the consistency of butter, and dissolving it in petroleum spirit, the solvent being evaporated off after repeated treatment of the solution with animal charcoal.

Characters of the Commercial Products. On redistillation, benzine obtained from the crude petroleum of the United States may be divided into gasoline and a number of other less volatile products, but gasoline itself is sometimes further subdivided into cymogene, rhigolene, and gasoline. Cymogene boils at 32° F., and can therefore be preserved only in a liquid state in a freezing mixture, or under pressure, while rhigolene has a boiling-point of 65° F. These products, which have in admixture a specific gravity of ·636, have been used for surgical purposes as local anæsthetics. A highly volatile product, of specific gravity ·625, obtained from gasoline, has also been employed for the same purpose in admixture with sulphuric ether. The generic term of *petroleum ether* is applied to the product in question (not the mixture), but various other descriptions of petroleum ether of higher specific gravity and lower volatility (or higher boiling-point) are made in this country. Gasoline, the specific gravity of which formerly ranged from ·642 to ·648, is used to carburet air in what are known as *air-gas machines*, for burning as an illuminant, and is also largely employed as fuel in cooking-stoves in the United States. The term "gasoline" is now commonly applied in the United States to any description of motor spirit. For use in the internal-combustion engines of motor-cars, preference was formerly given to a petroleum spirit of ·680 specific gravity imported from the United States or manufactured in this country, but it has become difficult to obtain adequate supplies of this product, and within recent years there has been a progressive increase in the specific gravity of the spirit employed for the purpose. Moreover, a large proportion of the benzine now imported comes from the Dutch East Indies, and this product has a lower boiling-point in relation to the specific gravity than that of the American spirit, so that the specific gravity has ceased to be a trustworthy guide to the volatility of the product unless the origin of the spirit is also taken into account. Petroleum spirit from Rumanian petroleum is also now an article of commerce in this country.



1. SWEATING-STOVES FOR THE PURIFICATION OF PARAFFIN WAX MADE FROM SHALE OIL

Refined Oil. The refined oil (kerosene) obtained from the crude petroleum of the United States is of several descriptions, but only two of these—the ordinary American lamp-oil of commerce, known under the brands of Tea Rose, Royal Daylight, etc., and water-white or high-test oils, sold under the brands of White Rose, Snowflake, etc.—are imported into this country. The ordinary oil is usually of a pale straw colour, and has a specific gravity of about ·800. Its flash-point is generally not much above the legal limit of 73° F. (Abel test). The higher grade of oil, of which the average crude petroleum yields only about 15 per cent. or 16 per cent., is colourless, or nearly so, and has a specific gravity of about ·79. Its flash-point is over 100° F. (Abel test). There is also manufactured to a small extent a burning oil having a specific gravity of ·825 to ·830 and a flash-point of about 250° F.

(Abel test). Of this oil, which is usually known as *mineral colza oil*, about 10 per cent. may be obtained from the crude petroleum.

Russian crude petroleum furnishes parallel products of a somewhat different character. The yield of benzine is usually much lower, and the ordinary kerosene, obtained to the extent of only from 27 per cent. to 40 per cent, of the crude oil, has the comparatively high specific gravity of ·825, and a flash-point of about 85° F. (Abel test). The most important commercial product is the residuum, which, under the name of *ostatki*, is very largely employed as liquid fuel.

Kerosene is also imported into Great Britain from Rumania.

Of mineral oils for lubricating purposes an extensive series is imported from the United States and Russia under the names of spindle oil, engine oil, cylinder oil, valve oil, etc., the names indicating the general characters and uses. These oils are of various specific gravities, flash-points, and viscosities, according to the purposes for which they are intended.

Oils for gas-making and other purposes, intermediate in physical characters between the burning oils and the lubricating oils, are also imported.

Methods of Testing. Although, for commercial purposes, many tests are applied to petroleum products in order to ascertain their suitability for the uses to which they are intended to be put, the legal enactments are based solely on the determination of the risk of fire as measured by the temperature at which inflammable vapour is given off by the oil, the test being known as that of *flashing-point* or *flash-point*, and on this basis regulations are made respecting the keeping, carriage, and handling of such crude oils and products as are regarded as dangerous. The early petroleum legislation in the United Kingdom fixed the standard of flash-point at 100° F., the test being performed by heating a sample of the oil in a small open cup placed in a water-bath, the arrangement resembling a carpenter's gluepot, and passing a small flame at intervals across the surface of the oil as the temperature rose above 90° F., until a pale blue flicker or flash was observed.

The Abel Test for Flash-point. Owing to the unsatisfactory results furnished by this comparatively rough method of testing, the Petroleum Act of 1879 was passed, with the object of substituting the "Abel test," devised by the late Sir Frederick Abel, in which a closed cup is used. The Abel testing instrument consists of a cylindrical oil-vessel, fitted with a thermometer and provided with a cover, in which there are three openings. These openings are covered and uncovered by means of a slide working in guides, and having corresponding perforations. As the slide is drawn back to open the cup, it automatically tilts a small test-lamp, so that the flame of the latter just enters the oil-vessel. The oil-cup is placed in an air-jacketed space in an outer vessel containing water previously heated, and, in order to ensure uniform results, the test has to be performed in accordance with specific directions relating to the filling of the oil-cup, the initial temperature of the water-bath, the size of the test flame, and the time occupied in applying this flame. The first application of the flame is made when the oil attains a temperature of 66° F., and the standard flashing-point is fixed at 73° F., this temperature corresponding to the old standard of 100° F. in the open cup. A modification of this apparatus, in which the slide

2. A MOUND OF SPENT SHALE, WITH STORAGE TANKS FOR THE OIL MADE FROM IT

This photograph and that on the opposite page are reproduced by courtesy of the Pumpherston Oil Company, Glasgow

is moved by clockwork, is used for testing petroleum under the Indian Petroleum Act, the minimum flashing-point for safe oil being fixed at 76° F., with a correction for the effect of variations in atmospheric pressure. In India the application of the test flame is directed to be begun at a relatively earlier stage of the test than in colder countries, with the object of getting rid of the vapour which is liable to be disengaged from the oil in filling the cup in a tropical climate, as this may cause a flash to occur prematurely.

Testing Lubricating Oils. For testing the flash-point of lubricating oils, another modification of the Abel apparatus, known as the Pensky-Martens tester, is largely used. The oil-cup of this instrument is fitted with a stirrer to ensure uniformity in the temperature of the contents of the cup, and the application of the test flame (furnished by coal-gas issuing from a small jet) is effected by means of a rotating vertical rod. The oil-cup is heated to the requisite temperature in a cast-iron air bath surrounded by a brass jacket.

The viscosity of lubricating oils is also tested, for this affords a measure of the relative lubricating values of the oils. The instruments employed in making this test are termed *viscometers*, and their action is usually based upon the principle of determining the time occupied in the outflow of a specified quantity of the oil through a jet or small orifice at a given temperature. The standard instrument in this country is the Redwood viscometer, while on the European continent a somewhat similar form of apparatus, known as the Engler viscometer, is largely used.

The commercial value of paraffin wax is largely governed by the so-called *melting point* (which is really the setting point or solidifying point) of the material. This is determined by melting a small quantity in a test tube and stirring it with a sensitive thermometer while the tube and its contents are allowed to cool slowly in the air until a point is reached at which the cooling is arrested by the heat given out by the solidifying paraffin, and the mercurial column remains stationary for a short time. The temperature recorded by the thermometer when this occurs is the melting point.

Transport. Refined oil (kerosene) is chiefly transported in bulk in tank steamships, tank barges, tank railway waggons, similar to those already referred to as being employed in the carriage of crude petroleum, and tank road waggons, the aim of modern practice being to cheapen the cost of transport by keeping the oil in bulk from the time it leaves the refinery until it reaches the lamp in which it is burned. The use of the 40-gallon wooden barrels in which this product was at one time so largely distributed has, accordingly, been almost entirely superseded, but "cases," which are wooden boxes, each holding two tin cans of 4-gal. capacity, are still largely employed for sending the oil into sparsely populated countries, especially in the tropics.

At the present time the Atlantic petroleum steamship fleet is a large one, and some of the vessels are of great capacity. The engines and boilers are sometimes placed amidships and sometimes at the after end. The tanks are formed by the skin of the ship, a decking, and a series of transverse bulkheads, with a central fore-and-aft bulkhead, and they are isolated from the stokehold and engine-room by a double bulkhead or coffer-dam, two of these being required when the engines are amidships, and the screw-shaft being then carried through an oil-tight tunnel. The most important fundamental principle of construction lies in the provision of expansion trunks, extending upwards from the top of the tanks, by means of which the contraction and expansion of the oil under changes of temperature are allowed for, and the tanks always remain full. If it were not for this arrangement the tanks would be liable to overflow or to become partially empty, when the oil would be liable to be set in oscillation and the safety of the ship would be imperilled. The oil is delivered into these steamships by pipe-lines, and is discharged at the rate of hundreds of tons per hour by the vessel's powerful pumps.

Lubricating oils are now very largely shipped from the United States in bulk, and wholly so from Russia. The gas-oil used by gas companies in the manufacture of carburetted water-gas, and in the enriching of coal-gas, is also shipped in bulk.

Paraffin scale for candle-making is transported in barrels, the material being frequently run into the packages in a melted state; and paraffin wax is packed in cases.

Under the bylaws of the Thames Conservancy, petroleum spirit, now almost entirely imported in bulk, is landed at Thames Haven, and is brought up the river in licensed tank barges.

Scottish and Other Oil Shales. The bituminous shales occurring in Scotland (Linlithgow and Midlothian), France (Autun), New South Wales, New Zealand, Nova Scotia, Serbia, and elsewhere, yield on destructive distillation, besides ammonia, a series of commercial products, including burning oil, lubricating oils, and solid paraffin, resembling those obtained from crude petroleum. The Scottish shales usually give from 18 gal. to 30 gal. of crude oil to the ton, and in some cases as much as 60 lb. to 70 lb. of sulphate of ammonia. A rich description of shale is mined in New South Wales, which furnishes over 100 gal. of oil to the ton, and some of the New Zealand shale is remarkable for the very large proportion of solid paraffin obtainable from the products of distillation.

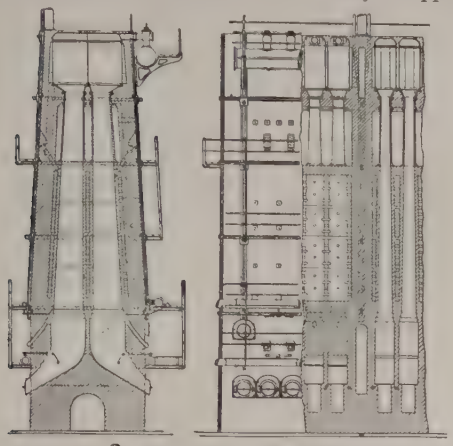
Scottish Shale Oil Industry. The industry has suffered severely from the competition of imported petroleum products, but adversity has been met in a manner deserving of the highest praise, remarkable improvements in plant having been made, and economics effected in working costs. In this connection it should be pointed out that in distilling shale there is an additional source of profit in the ammonia obtained with the oil, and that of the most valuable of the oil products —namely, the solid paraffin—shale oil usually gives a comparatively large yield.

Oil shale is mined similarly to coal, is screened at the mine, and on reaching the works is broken by machinery into flat pieces about six inches square.

Shale Retorts. Horizontal retorts, similar to those used in coal-gas manufacture, were at first adopted for the distillation of the shale, but at an early date these were replaced by vertical retorts, and steam was injected into the retorts to carry off the oil vapours. Distillation under reduced pressure was subsequently introduced, and the spent shale was utilised as fuel for heating the retorts. The use of steam increased the yield of oil by 20 per cent., and by subjecting the shale to a higher temperature in the presence of steam after the oil had been driven off at a moderate heat, a much larger proportion of the nitrogen was obtained in the form of ammonia.

Various improvements in shale retorts were made from time to time by Young, Henderson, Beilby, Fyfe, and others, with the objects of diminishing the cost of working and increasing the yield of oil

and ammonia. The retorts at present in use, of which one type is shown in 3, hold about 30 cwt. and are about 28 ft. in height; they consist of an upper portion of cast iron, surmounted by a hopper,



3. SHALE OIL RETORTS

and a lower portion of firebrick. They are set in benches in a combustion chamber, and are heated through the agency of a gas-producer. The upper part is heated to dull redness, and the lower to a bright, red heat.

Retorting. The process of distillation is a continuous one, the spent shale being gradually withdrawn from the base of the retort, and a corresponding quantity of fresh shale entering from the hopper at the top. About twenty-four hours is occupied in the passage of the shale through the retort.

The vapours issuing from the distilling charge, amounting to about 3,000 cubic ft. per ton of shale, pass from the top of the retort into a vertical tube condenser, where the oil and ammoniacal liquor are separated. The uncondensed gas may be used for lighting or heating, or the very volatile liquid hydrocarbons which it contains may be obtained by passing it through a scrubber, and the residual gas, which then has no illuminating power, is utilised as fuel.

The ammoniacal liquor from the condenser is distilled, and the liberated ammonia is brought into contact with sulphuric acid, with which it combines to form commercial sulphate of ammonia.

Shale Oil Refining. The crude shale oil, which is of a dark green colour, is subjected to a continuous process of fractional distillation substantially similar to that already described as applied to crude petroleum, and is thus separated into light and heavy oils and paraffin wax, steam being passed into the stills in order to facilitate the operation and prevent injury to the products by overheating. The light oil furnishes a small proportion of naphtha on redistillation, after treatment with acid and alkali, the remainder of the light oil consisting of the burning oil, or paraffin oil, used in lamps. The heavy oil is cooled, so as to cause the solid hydrocarbons to crystallise out, and is then passed through filter-presses, which separate the paraffin from the oil.

Paraffin Refining. The crude paraffin was formerly refined by dissolving it in the naphtha obtained from the light oil distillate, allowing it to crystallise out in shallow trays, and pressing the cakes thus obtained. This method of treatment has, however, been superseded by the "sweating" process, in which the paraffin is pumped, in a melted state, into shallow trays, supported above transverse heating-pipes in a closed chamber or stove. Each tray is fitted with a perforated strainer, of about 16 apertures to the inch, which is covered to the depth of about half an inch with cold water, the melted paraffin floating on this layer of water above the strainer. When the paraffin has solidified, the water is drawn off, and the cake of paraffin rests on the strainer. Steam is then passed through the heating-pipes, and the temperature of the stove is slowly and cautiously raised to the point at which sweating takes place. The effect of the heat so applied is to cause the softer and more fusible portion of the paraffin to melt and drain through the strainer, carrying with it the impurities, and this portion is drawn off. The hard paraffin remaining on the strainer is then melted by further raising the temperature of the stove, drawn off from the tray, decolorised by agitation for some time with animal charcoal and cast into cakes for sale to the candle makers.

Yield of Products. The heavy oil from which the paraffin has been separated in the filter presses yields, by further refining, a series of lubricating oils of various specific gravities, flash-points, and viscosities. The proportions of the various commercial products yielded by Scottish shale vary with the nature of the shale and the process of manufacture, but may be taken as ordinarily being about 3 per cent. to 6 per cent. of naphtha (including gasoline), 39 per cent. of burning oil (including gas oil), 18 per cent. of lubricating oils, and 10 per cent. of paraffin (refined and semi-refined), the loss being thus no less than 30 per cent. The loss is very large compared with that sustained in the refining of crude petroleum, and indicates the disadvantage under which the shale-oil refiner works. Before he is in the same position as the petroleum refiner he has to mine and break the shale and subject it to destructive distillation, and his crude oil is far more difficult to refine than the raw material with which the petroleum refiner usually has to deal. Against the extra expenditure which this entails the profit on the sulphate of ammonia is to be set, and it is this, coupled with the large yield of the valuable product, paraffin, which has enabled the shale-oil industry effectively to meet the competition of petroleum.

French Shale Oil Industry. In France the distillation of shale was begun as far back as 1830, and the French industry is, therefore, much older than the Scottish, though it has made less progress, and is of smaller commercial importance. The chief centres of the industry are at Autun, and Buxière-les-Mines. The shale yields only about 17¼ gal. of oil to the ton, and 5 per cent. to 7 per cent. of sulphate of ammonia. The oil is fractionated and refined in the same manner as Scottish shale oil, but is less easily converted into commercial products of satisfactory quality. It yields about 3·5 per cent. of naphtha, 19 per cent. of burning oil, 23 per cent. of gas oil, 8 per cent. of pale oil, 17 per cent. to 18 per cent. of lubricating oils, and 2·7 per cent. of refined paraffin. The industry has declined since the removal of the heavy import duties on crude petroleum, which formerly protected it.

Australian and New Zealand Shale Oil. In New South Wales, a so-called "kerosene shale," resembling cannel coal, has been mined and distilled since 1865. Some of this mineral yields over 100 gal of oil to the ton. The retorting has latterly been carried on near Torbane, west of the Blue Mountains, and about 130 miles from Sydney,

the crude oil being transported by rail in tank waggons to a refinery at Hartley Vale. A few years ago an English company was formed to develop the industry on a large scale.

Bituminous shales occur in the upper portions of the coal measures of New Zealand, and that which is found at Orepuki yields a crude oil containing a remarkably large proportion of solid hydrocarbons.

The Brown Coal-tar Industry. In Prussian Saxony, the destructive distillation of lignite, and conversion of the tar obtained into commercial products resembling those yielded by shale oil, constitutes an industry of local importance. The tar is fractionally distilled under reduced pressure, with the object of preventing the decomposition which would otherwise occur, and in this manner from 8 per cent. to 30 per cent. of light oil, 15 per cent. to 30 per cent. of lubricating oils, and 1·5 per cent. to 12 per cent. of paraffin, are made from it. In other respects the process adopted resembles that already described as applied in the refining of shale oil.

Kimmeridge Shale. The extensive deposits of shale in Dorsetshire admit of being mined at a low cost, and give a satisfactory yield of crude oil, but the refining of this oil presents exceptional difficulties which have hitherto stood in the way of its utilisation.

Uses of Petroleum. Crude petroleum has from the earliest times been employed as a curative agent, especially in cutaneous affections of men and animals, in the treatment of wounds, and for the relief of strains and rheumatism. For pharmaceutical purposes crude petroleum is no longer in general use by civilised communities, but the well-known product vaseline is very largely employed, both alone, and as a means of applying medicinal substances, where local action, rather than absorption, is desired, its physical and chemical characters rendering it superior to an animal fat for such a purpose.

Vaseline is also largely used as a protective coating for surfaces liable to injury from damp and exposure to the air; and it is an important ingredient of the smokeless explosive, cordite.

In surgery the more volatile products of petroleum have been found valuable as anæsthetics, especially in producing local insensibility by the cold resulting from rapid evaporation.

Petroleum Lighting and Heating. As a source of light and heat, petroleum and natural gas have been favourably known for ages, and at the beginning of the second half of the past century the petroleum or paraffin lamp and the paraffin candle became recognised as among the necessaries of civilised life. Indeed, it may be said that no modern article of commerce has done as much as refined petroleum to promote comfort and extend man's capacity for leading a fruitful life, for it has encouraged domesticity and has largely increased the number of hours available for study. Recognising this, some have even gone as far as to say that the progress of a nation in civilisation may be measured by the consumption of petroleum per head of population.

The illuminating agent supplied by the gas companies is often largely composed of carburetted water-gas, in the manufacture of which great quantities of petroleum are used. In some of the principal cities of the United States the latter gas has, in fact, entirely replaced coal-gas. Volatile petroleum products are also used in enriching coal-gas, so as to bring its illuminating power up to the required standard.

Petroleum-driven Vehicles. It is scarcely necessary to mention the highly important part which petroleum spirit is now playing in providing the means of locomotion through the medium of public service vehicles (motor omnibuses) in the great cities, and private self-propelled carriages throughout the country.

The advent of the private motor-car has directed renewed attention to the splendid high-roads of this country, and has revived the ancient glories of wayside hostelries, with great advantage to the mental and physical condition of those who are able to employ, temperately, this means of travelling.

It is well known that the source of power in that modern addition to the belligerent marine, the submarine, is petroleum, these vessels being propelled by internal-combustion motors while on the surface of the water, and receiving their stores of the electricity which drives them beneath the surface from the same source.

As liquid fuel for use in steam raising for power purposes, both on land and at sea, as well as in metallurgical and other work, petroleum has now taken a most important place as a heating agent of far higher efficiency than even the best steam coal, but the steam-engine is now being largely replaced by internal-combustion engines of the Diesel type, which furnish a much more economical source of power.

Lubricating Oils. The lubricating properties of petroleum were recognised at a very early date, and one of the first applications of the more viscous descriptions of this product found on or near the surface of the ground was in the greasing of the wooden axles of primitive carts. The manufacture of lubricating oils from petroleum has long since been brought to a high degree of excellence, and such oils have now very largely replaced the animal and vegetable oils and fats previously employed for the purpose.

There is a large consumption of the softer and more fusible kinds of paraffin for rendering wooden matches readily inflammable. Paraffin also is or has been used in waterproofing match-heads; in strengthening and waterproofing woollen fabrics; as a "resist" in dyeing, the parts of the fabric coated with it rejecting the dye; for lining brewers' vats and beer barrels; for preserving stone, wood, eggs, meat, fruit, and flowers; for glazing, protecting, and waterproofing paper; as an adjunct to starch for glazing linen; as an auxiliary to soap for laundry work; as an electrical insulator; as a substitute for fat for absorbing perfume from flower petals; and as an easily-moulded material in making ship models.

Petroleum in Soap Manufacture. The detergent properties of petroleum account for its extensive introduction into household soaps. Petroleum is also the active ingredient of certain insecticides. Petroleum spirit is largely employed in the process known as dry-cleaning; in the extraction of grease from leather; as a solvent for various purposes, and especially, in a carefully prepared form, as a substitute for oil of turpentine for use in making paints and varnishes.

Among other uses of petroleum may be mentioned those of ore-concentration, and the removal of fusel oil from crude molasses spirit.

In the form of "westrumite," and other preparations, petroleum has been successfully employed as a dressing for road surfaces to prevent disintegration and the raising of dust, its slower rate of evaporation rendering its action more lasting than that of water.

Many patents have been granted for the solidification of petroleum, chiefly with a view to the use of the product as a fuel, either alone, or in admixture with coal-dust or other combustible substances, in the form of briquettes. Among the solidifying agents which have been specified for this use are resin soap, extract of quillaia bark, lichen extract, fish glue, casein, and glue (with formalin as a hardening agent).

A product known as soluble petroleum is prepared by partially saponifying resin previously dissolved in the oil, or by blowing air through a mixture of resin oil and caustic soda solution, and adding to the jelly-like mass thus obtained an aqueous solution of a fatty oil soap and mineral lubricating oil. The product is intended to be employed, in admixture with water, as a lubricant, especially for tools used in boring and cutting metals, and is stated to have given excellent results.

Petroleum as an Illuminating Agent. Petroleum or paraffin lamps are usually fitted either with a single or duplex flat-wick burner or with an Argand burner, the former being more largely used in Great Britain and America, while the Argand, or annular wick type, is more popular on the Continent. The latter type of lamp is provided with a central air-supply channel, sometimes extending down through the oil-container to the base, and a disc or button is usually fixed at a short distance above the top of the wick-tube, so that the upward current of air induced by the heated chimney is deflected outwards and caused to impinge on the inner surface of the flame. Air is also supplied separately to the outer surface. Burners of the duplex type are usually fitted with an extinguisher, which is sometimes arranged to come into action automatically in the event of the lamp being overturned.

In one form of lamp the petroleum is vaporised and the vapour is conducted into an inverted Argand burner; in another a mixture of petroleum vapour and air, burning with a non-luminous flame, is employed to heat a Welsbach incandescent mantle.

A given amount of light was formerly obtainable from mineral oil at a much lower cost than from gas, but the general use of the incandescent mantle has so largely added to the efficiency of the latter illuminating agent that the comparative positions in respect of cost have been reversed, unless a mantle be also used with oil.

Petroleum Lamps. The subject of accidents with mineral oil lamps has in past years attracted considerable attention, and it has been contended that the minimum legal flash-point of 73° F. should be raised to 100° F. in the interest of public safety.

Formerly all lamp accidents were described in the newspapers as explosions, but investigation has shown that at least 75 per cent. or 80 per cent. of them have been due to the overturning or dropping of the lamp or to its fracture from some other cause. In fact, with a properly constructed lamp, and with ordinary care and intelligence in its use, an explosion ought never to occur.

In choosing a table lamp the purchaser should note whether it has sufficient stability, or, in other words, whether it is easily upset or not. If the lamp has the usual pedestal its attachment to the oil container should be substantial. The oil container should be of sufficient strength to withstand a fall from the height of a table on to a bare wooden floor without being broken or allowing the oil to escape, and, notwithstanding the merits of glass, it is safer to have a well-made container of metal. The burner should be securely attached to the oil container, and there should be no opening in it by which flame can communicate with the interior of the oil container. The burner should admit of being taken to pieces for cleaning, and it should be fitted with a good, substantial chimney gallery.

The Use of a Lamp. In the care and use of the lamp, the following should be borne in mind:

1. The wick should quite fill the wick-tube without having to be squeezed into it.
2. Before using, the wick should be dried at the fire, and then immediately soaked with oil.
3. Wicks should be in lengths of not more than 10 in., and should always reach the bottom of the oil container.
4. It is well to change the wick after two months' use.
5. See that the chimney of the lamp fits properly, and is held sufficiently tight so as not to fall off when the lamp is used.
6. When a new wick or chimney is required, it is always advisable to take the burner to the shop so that it may be properly fitted.
7. The burner should be taken to pieces and thoroughly cleansed at least once a month, and all burnt pieces of wick, dead flies, etc., should be carefully removed.
8. Never refill the lamp when it is alight or near a fire or other light.
9. After filling, see that the burner is properly fixed on, and if there is a side filling-hole, be careful to screw in the plug.
10. Before lighting, remove the burnt crust of the wick.
11. Be careful not to spill oil in filling, and if any is spilt on the lamp, wipe it off.
12. Before lighting, see that the slit in the cone of the burner is exactly over the wick-tube, so that the flame will not touch the metal.
13. When first lit, the wick should be partially turned down, and then gradually raised, but not so as to smoke. When the edge of the flame is orange coloured the lamp is not burning properly, and the burner should be examined.
14. Do not continue to burn the oil until it is completely exhausted. It is best to keep the lamp well filled.
15. Lamps which have no extinguisher should be put out thus: The wick should be turned down until there is only a small flickering flame, care being taken not to turn down so far that the wick falls into the oil container. The small flame may be extinguished by placing a piece of flat tin or card on the top of the chimney or by blowing across the top of the chimney. Never blow down the chimney.
16. Never use a lamp which is broken or in any way out of order, or a chimney which is cracked. If any part comes loose, or is out of shape or defective, it should be taken to a lamp shop to be repaired.
17. Always place the lamp in a secure place, and on a level surface, and never on a rickety table, or in any position where it could be easily upset. Hanging lamps should not be put on insecure nails in the wall.
18. Table lamps should not be carried about more than is necessary, and nothing else should be carried at the same time. Heavy lamps should be carried in both hands. The greater number of lamp accidents have been caused by dropping a lamp while it was being carried.
19. Lamps should not be turned down except for the purpose of putting them out. If turned low, the oil is liable to be unduly heated.
20. Should a person's clothes become ignited, the flames should be smothered with a hearth-rug, blanket, woollen tablecloth, or wet towel.
21. Never pour oil on a fire.

Outdoor Lighting. Various special kinds of lamps are used in the open air. For use on ships and on the rolling-stock of railways it is necessary that the lamps shall be constructed so that the air supply is not affected by the force of the wind, and that water cannot gain entrance. In the lighting of large areas during building and engineering operations, extensive use is made of lamps of the Lucigen and Wells type, in which the oil is forced up from a closed receiver by compressed air and sprayed through a heated burner, a light of 2,000 to 2,500 candle-power being given. In the Kitson lamp for street lighting compressed air is also used to raise the oil to the burner, where it is vaporised, and by means of the flame thus obtained a large mantle is heated to incandescence. A light of 1,000-candle power is thus produced at the very low cost of 1d. per 1,000 candle-hours. This represents the highest economy hitherto obtained in the use of mineral oil, and compares with 2¼d. for the incandescent table lamp, or 7½d. for the duplex lamp. The same amount of light obtained from coal-gas on the pressure incandescence system (with

which the Kitson system of oil burning is fairly comparable) probably costs, on the average, about 1¾d.; with the ordinary incandescent mantle as used in dwellings, 2¼d. (the same as oil); or with a fish-tail burner, about 1s. 6d. The comparative cost of incandescence electric light may be put at 1s. 2d.

Air-gas. To some extent in this country, and far more largely in America, air saturated with the vapour of petroleum spirit is employed as an illuminating agent under the name of *air-gas*, and various mechanical devices are employed to effect uniform saturation under varying conditions. The air-gas may be used with ordinary gas-burners, or, after admixture with a further quantity of air, may be burned under a mantle. A portable lamp has been introduced in which the spirit is absorbed by a porous material and gradually vaporised, the heavy vapour flowing by gravitation to the burner and drawing in the air required to produce a non-luminous flame for heating a mantle.

Oil-gas. In order to produce a permanent gas of high illuminating power (50 candles) capable of bearing compression to 10 atmospheres, for use in lighting railway trains, buoys, and lighthouses, a suitable description of petroleum is slowly introduced into a retort maintained at a cherry-red heat.

Carburetted Water-gas. A similar description of oil is also very largely used by the principal gas companies in the manufacture of carburetted water-gas, and as a substitute for cannel coal in enriching coal-gas. In the Lowe system, used in English gasworks, water-gas is formed by blowing steam through incandescent coke or anthracite in a generator. This gas is passed through a superheater, where the oil is added, and the mixture of oil-vapour and water-gas is then taken through another superheater of large size in which the hydrocarbons are converted into permanent gas.

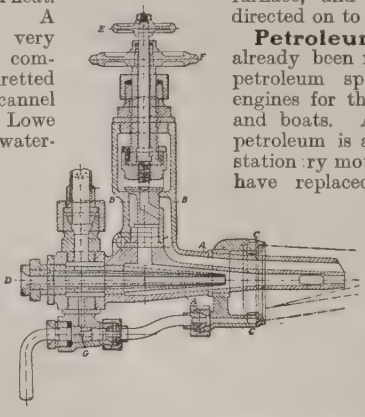
Natural Gas. Certain portions of the petroliferous territories of the United States yield natural gas, which is largely used for lighting and heating, as well as in the manufacture of lamp-black. The gas may usually be burned with an Argand or fish-tail burner, but the best results are obtained with a mantle. For some time natural gas was used to light the railway and town at Heathfield, in Sussex, where it was accidentally discovered, [See page 5417.]

Liquid Fuel. Crude petroleum is employed in the oil-fields, for steam raising, and in refineries, as a means of heating the stills; but the presence of very volatile constituents is a source of risk in storage and handling. Accordingly, either petroleum residuum, which remains in the stills after the separation of the kerosene from such crude oil as that of the Russian oil-fields, or a suitable distillate, with a specified minimum flash-point, is employed on steamships and locomotives, as well as in most industrial establishments where liquid fuel has taken the place of coal. In the British mercantile marine the minimum flash-point is 150° F., but for use in the Navy, liquid fuel is required to have a flash-point of 175° F. It is also needful that the oil should bear exposure to a low temperature, say 32° F., without solidifying.

On the Caspian Sea, and on the railways of Southern Russia, petroleum residuum (ostatki) is the sole fuel; and in California the consumption of liquid fuel has reached very large dimensions. It is common knowledge that the British Admiralty has adopted oil fuel as an adjunct to coal in the modern battleships and armoured cruisers.

Oil fuel is also not only largely used in the furnaces of stationary steam boilers, but is giving highly satisfactory results in metallurgical work, glass melting, and the like.

The oil is usually burned by spraying or atomising it by means of steam, but in some cases is broken up into small particles by forcing it under high pressure through a small orifice. The Holden burner, employed in this country on the locomotives of the Great Eastern Railway, is shown in **4**. The oil is admitted to the interior of the coned body AA through a regulating valve, BB. The annular steam jet D is provided with a central air-passage. CC is an annular chamber to which steam is admitted, and from which it escapes in jets through six small orifices. E and F are wheels by means of which the valves controlling the supply of fuel may be opened or closed. The cock G regulates the supply of steam to CC. The burner is fixed in the front of the furnace, and the intensely hot flame is directed on to a sloping bridge of firebrick.



4. HOLDEN BURNER FOR LIQUID FUEL

Petroleum Engines. Reference has already been made to the extensive use of petroleum spirit in internal-combustion engines for the propulsion of road vehicles and boats. A less volatile description of petroleum is also very largely employed in stationary motors, which in many instances have replaced steam engines and gas engines. In steam engines of moderate dimensions only 12 per cent. of the heat-value of the fuel burned in the boiler furnace appears in the engine as indicated work, whereas, in the internal-combustion engine, the proportion of heat rendered effective is, in many cases, more than double that percentage, and in the Diesel engine is as high as 37 per cent. The superior economy of the oil engine is therefore very marked. Preference is generally given to those engines in which one explosion occurs for each two revolutions of the crank-shaft. The first forward stroke of the piston draws in the explosive charge of oil or oil-vapour and air, and the return stroke compresses it. During the next forward stroke, the explosion drives the piston, and on the return stroke the products of combustion are discharged from the cylinder. The Priestman, Hornsby-Akroyd, Trusty, Tangye, and Diesel engines may be taken as typical of the principal forms of oil-motors. The Priestman engine is fitted with a spray-producer, as well as a vaporiser, and the charge is ignited by means of an electric spark. In the Hornsby-Akroyd engine, the explosion is effected by injecting the oil into a red-hot chamber, into which heated air is forced by the piston. In the Trusty engine, the oil is vaporised and the charge is fired by means of an igniting-tube maintained at a red heat. The Tangye engine also has a vaporiser and an ignition-tube. In the Diesel engine, the air admitted to the cylinder is heated, by very high compression, to such a temperature as to cause the immediate combustion of the injected charge of oil.

BOVERTON REDWOOD

The Ambiguous Case. Worked Examples Illustrating the Four Cases. Examples and Answers.

SOLUTION OF TRIANGLES

44. Case Two of Solution of Triangles. Given one side and two angles, say a, B, and C. Since the three angles of a triangle equal 180°, we have $A = 180° - B - C$.

Again, $\frac{\sin A}{a} = \frac{\sin B}{b}$, so that $b = \frac{a \cdot \sin B}{\sin A}$.

Similarly, $c = \frac{a \cdot \sin C}{\sin A}$.

These two equations give the values of b and c.

Adapting these formulæ to the use of logarithms, we have

$$\log b = \log \frac{a \cdot \sin B}{\sin A}$$
$$= \log a + \log \sin B - \log \sin A$$
$$= \log a + (\mathrm{L} \sin B - 10) - (\mathrm{L} \sin A - 10)$$

or, $\log b = \log a + \mathrm{L} \sin B - \mathrm{L} \sin A$.

Similarly,

$\log c = \log a + \mathrm{L} \sin C - \mathrm{L} \sin A$.

45. Case Three of Solution of Triangles. Given two sides and the included angle, say b, c, and A. We have $B + C = 180° - A$, which gives the value of $(B + C)$. Then, from Article **40**,

$$\tan \frac{B - C}{2} = \frac{b - c}{b + c} \cdot \cot \frac{A}{2}.$$

This gives the value of $\frac{B - C}{2}$, and therefore of $(B - C)$. Having obtained the values of $(B + C)$ and $(B - C)$, the values of B and C can be found.

Finally, since $\frac{a}{\sin A} = \frac{b}{\sin B}$, or $a = \frac{b \cdot \sin A}{\sin B}$, we obtain the value of a.

To arrange the method for logarithmic work we proceed thus :

$$\tan \frac{B - C}{2} = \frac{b - c}{b + c} \cdot \cot \frac{A}{2}.$$

$$\therefore \log \tan \frac{B - C}{2}$$
$$= \log (b - c) - \log (b + c) + \log \cot \frac{A}{2};$$

or, adding 10 to each side of the equation,

$$\mathrm{L} \tan \frac{B - C}{2} = \log (b - c) - \log (b + c) + \mathrm{L} \cot \frac{A}{2}.$$

And, as in Article **44**, from $a = \frac{b \cdot \sin A}{\sin B}$, we get

$$\log a = \log b + \mathrm{L} \sin A - \mathrm{L} \sin B.$$

46. Case Four of Solution of Triangles. Given two sides and the angle opposite one of them, say b, c, and B.

Since, $\frac{\sin C}{c} = \frac{\sin B}{b}$,

$$\therefore \sin C = \frac{c \cdot \sin B}{b}. \quad \ldots \quad (1)$$

C can be found from this equation. Then, having found C,

$$A = 180° - B - C.$$

The value of a is found, as in the last article, from the formula $a = \frac{b \cdot \sin A}{\sin B}$.

47. The Ambiguous Case. In the case considered in Article **46**, the solution of equation (1) gives the value of the *sine* of C. Now, when C is an angle of a triangle, and the value of *sin* C is known, C itself may have *two* values, one of them being less than 90°, and the other being between 90° and 180°.

Hence, there *may* be *two* triangles in which b, c, and B have the given magnitudes. Whether this is so may be decided as follows :

1. If B (the given angle) is *greater than* 90°, C must be *less than* 90°, since any two angles of a triangle must be together less than two right angles. Therefore, when B is greater than 90°, there is only one triangle which satisfies the given conditions.

2. When B (the given angle) is less than 90°, four things have to be considered.

(i.) Is b less than $c \cdot \sin B$? If so, then, since $\sin C = \frac{c \cdot \sin B}{b}$, the value of sin C is greater than 1, which is impossible [Art. **15**]. In this case there is *no* triangle which satisfies the given conditions.

(ii.) b may be *equal* to $c \cdot \sin B$. We should then have $\sin C = 1$, and therefore $C = 90°$. In this case, then, there is only *one* triangle.

(iii.) If b is greater than $c \cdot \sin B$, but *less than* c, then B is less than C [Geometry, *Prop.* 21], and therefore C may be acute or obtuse. Hence, C may have either of the values found from the equation $\sin C = \frac{c \cdot \sin B}{b}$, and there will then be *two* triangles satisfying the given conditions. This is the *ambiguous case* in the solution of triangles.

(iv.) If b is equal to or greater than c, then B is equal to or greater than C. Hence, C must be an acute angle, and therefore there is again only one triangle satisfying the given conditions.

48. We shall conclude with examples illustrating each case in the solution of triangles.

Example 1. Given that $a = 40$, $b = 51$, $c = 43$,
$\log 2 = \cdot 3010300$, $\log 3 = \cdot 4771213$,
$\log 67 = 1 \cdot 8260747$.
$\mathrm{L} \tan 24° 44' 13'' = 9 \cdot 6634464$, find A.

Here, $a+b+c=40+51+43=134$.

$\therefore s=67,\ s-a=27,\ s-b=16,\ s-c=24.$

$$\therefore \text{L tan } \frac{A}{2} - 10$$
$$= \tfrac{1}{2}\{\log 16 + \log 24 - \log 67 - \log 27\}$$
$$= \tfrac{1}{2}\{\log 2^4 + \log 3 + \log 2^3 - \log 67 - \log 3^3\}$$
$$= \tfrac{1}{2}\{4\log 2 + \log 3 + 3\log 2 - \log 67 - 3\log 3$$
$$= \tfrac{1}{2}\{7\log 2 - 2\log 3 - \log 67\}$$
$$= \tfrac{1}{2}\{2{\cdot}1072100 - {\cdot}9542426 - 1{\cdot}8260747\}$$
$$= \tfrac{1}{2}\{2{\cdot}1072100 - 2{\cdot}7803173\}$$
$$= -\tfrac{1}{2}\{{\cdot}6731073\} = -{\cdot}3365536 = \bar{1}{\cdot}6634464.$$

$$\therefore \text{L tan } \frac{A}{2} = 9{\cdot}6634464$$
$$= \text{L tan } 24^\circ\ 44'\ 13''.$$
$$\therefore A = 2\times(24^\circ\ 44'\ 13'') = \underline{49^\circ\ 28'\ 26''}.$$

EXAMPLE 2. In the triangle ABC, the base AB is 1,000 ft. long, and the angles at A and B are 31° 20′ and 125° 19′ respectively. Find the length of AC.

We are given A, B, and c.

First, $C = 180^\circ - 31^\circ\ 20' - 125^\circ\ 19'$
$= 23^\circ\ 21'$.

Again,

$\log b = \log c + \text{L sin B} - \text{L sin C}$
$= \log 1000 + \text{L sin } 125^\circ\ 19' - \text{L sin } 23^\circ\ 21'$
$= \log 1000 + \text{L sin } 54^\circ\ 41' - \text{L sin } 23^\circ\ 21'$
$= 3 + 9{\cdot}9116739 - 9{\cdot}5980754$
$= 3{\cdot}3135985$
$= \log 2058{\cdot}725.$

Thus, AC = <u>2058·725 ft.</u>

EXAMPLE 3. Two sides of a triangle being 2265·4 ft. and 1779 ft., and the included angle being 58° 17′, find the remaining angles of the triangle.

Suppose $b = 2265{\cdot}4$, $c = 1779$, and $A = 58^\circ\ 17'$.

Then, $B + C = 180^\circ - 58^\circ\ 17' = 121^\circ\ 43'$.

Again, $\text{L tan } \dfrac{B-C}{2}$

$$= \log(b-c) - \log(b+c) + \text{L cot } \frac{A}{2}$$
$$= \log 486{\cdot}4 - \log 4044{\cdot}4 + \text{L cot } 29^\circ\ 8'\ 30''$$
$$= 2{\cdot}6869936 - 3{\cdot}6068541 + 10{\cdot}2537195$$
$$= 9{\cdot}3338590$$
$$= \text{L tan } 12^\circ\ 10'\ 21''.$$

$$\therefore \frac{B-C}{2} = 12^\circ\ 10'\ 21''$$

and $(B-C) = 24^\circ\ 20'\ 42''$.

But $(B+C) = 121^\circ\ 43'$.

$\therefore 2B = 146^\circ\ 3'\ 42''$

and $2C = 97^\circ\ 22'\ 18''$.

Hence, $B = 73^\circ\ 1'\ 51''$, $C = 48^\circ\ 41'\ 9''$ } *Ans.*

EXAMPLE 4. The lengths of two sides of a triangle are 5374·5 ft. and 1586·6 ft.; the angle opposite to the shorter side is 15° 11′. Calculate the other angles of the triangle, or of the triangles, if there are two.

Suppose $b = 1586{\cdot}6$ ft., $c = 5374{\cdot}5$ ft., and $B = 15^\circ\ 11'$. Then,

$\text{L sin C} = \log c + \text{L sin B} - \log b$
$= \log 5374{\cdot}5 + \text{L sin } 15^\circ\ 11' - \log 1586{\cdot}6$
$= 3{\cdot}7303381 + 9\ 4181495 - 3{\cdot}2004674$
$= 9{\cdot}9480202$
$= \text{L sin } 62^\circ\ 31'\ 23''.$

$\therefore C = 62^\circ\ 31'\ 23''$,

or $180^\circ - 62^\circ\ 31'\ 23'' = 117^\circ\ 28'\ 37''$.

And b is less than c, therefore both these values are admissible.

Thus there are two triangles.

(i.) $B = 15^\circ\ 11'$, $C = 62^\circ\ 31'\ 23''$, so that $A = 102^\circ\ 17'\ 37''$.

(ii.) $B = 15^\circ\ 11'$, $C = 117^\circ\ 28'\ 37''$, $A = 47^\circ\ 20'\ 23''$.

EXAMPLE 5.

Given that $C = 52^\circ\ 10'$, $b = 643$ yd., $c = 872$ yd., find the other angles.

$\text{L sin B} = \log b + \text{L sin C} - \log c$
$= \log 643 + \text{L sin } 52^\circ\ 10' - \log 872$
$= 2{\cdot}8082110 + 9{\cdot}8975162 - 2{\cdot}9405165$
$= 9{\cdot}7652107$
$= \text{L sin } 35^\circ\ 37'\ 7''.$

$\therefore B = 35^\circ\ 37'\ 7''$,

or, $180^\circ - 35^\circ\ 37'\ 7'' = 144^\circ\ 22'\ 53''$.

But b is less than c, therefore B must be less than C. Hence, the second value found for B is inadmissible.

Thus $B = 35^\circ\ 37'\ 7''$, and

$A = 180^\circ - 35^\circ\ 37'\ 7'' - 52^\circ\ 10' = 92^\circ\ 12'\ 53''$.

The above examples, with the exception of Example 1, are worked direct from the Tables of Logarithms. As already mentioned, the method of finding the logarithm corresponding to a given number or trigonometrical ratio, or the number or angle corresponding to a given logarithm, is explained in the book of logarithms.

EXAMPLES

1. When $a = 759{\cdot}3$, $b = 576{\cdot}2$, $c = 374{\cdot}5$, find C.

2. Find c, when $A = 50^\circ$, $C = 66^\circ$, a = 1000, having given

L sin 50° = 9·8842540
L sin 66° = 9·9607302
log 1·19255 = ·0764762

3. The angle A is 70° 30′, and the ratio of b to c is 5 : 3. Find the other angles, having given

L cot 35° 15′ = 10·1507464
L tan 19° 28′ 50″ = 9·5486864
log 2 = ·3010300

4. Find A, having given $b = 960$, $c = 1404$, B = 32° 15′

log 2 = ·3010300 — L cosec 32° 15′ = 10·2727724
log 3 = ·4771213 — L sin 21° 23′ = 9·5621316
log 13 = 1·1139434 — L sin 51° 18′ = 9·8923236

ANSWERS

1. 28° 35′ 39″
2. 1192·55
3. B = 74° 13′ 50″, C = 35° 16′ 10″
4. A = 96° 27′ or A = 19° 3′

H. J. ALLPORT

MATHEMATICS CONCLUDED—END OF GROUP 25

ONE OF THE WONDER-SIGHTS OF THE WORLD

THE MARVELLOUS SIGHTS THE TRAVELLER SEES IN SWITZERLAND—A CREVASSE 800 FEET DEEP ON THE GLACIER DU GÉANT

The Study of Town and Country at Home and Abroad.
Why, How, and Where to Go in Days of Peace.

EDUCATION THROUGH TRAVEL

FROM the earliest days when our forefathers began to study methods of education, they realised the need for education by travel. Shakespeare expressed the need in a sentence: "Home-keeping youths have ever homely wits." If that generalisation is taken as meaning that no one can be a cultured man of the world without seeing the world, it is, perhaps, too sweeping, for observation, reflection, science, and reading may conceivably educate a man fully, though they are exercised within the narrow sphere of rural life, provided he is endowed with much breadth and strength of mind. But such a man, though a possibility, remains a rarity. Without travel, he may be truly cultured; with travel, he would have attained a fuller development, and his powers would have expanded more freely under richer enjoyments.

Some Uses of Travel. Unless we travel we cannot hope to appreciate the influence of scenery on the minds of men. Though photography is useful in recalling what we have seen, it fails utterly to suggest the grandeur and beauty of the world to those who have not received direct impressions. Who, for example, can imagine the upper world of ice and snow? Unless we travel we cannot realise either the character or the economic conditions of people of other lands. We cannot form comparative opinions of the art of different regions and ages; nor can we come into vital touch with much of the world's most formative history. Reading of the past in a book is but a pale shadow of the history that may be felt on the scenes of its enactment. The increment of knowledge and experience from travel alters more or less insensibly our point of view, even of familiar things. Further, it may be placed to the credit of travel that it stimulates a practical knowledge of languages, and at the same time is one of the most refreshing forms of recreation.

Preparation for Travel. Travel, then, being so important, it is well that everyone should prepare for it in some measure, and map out his life so as to admit of it, sooner or later. All successful travel depends in a large degree on preparation. The traveller must know beforehand exactly where he is going, and what he ought to see in each place. Even if he goes abroad at first with a crowd, conducted by an agency, he should study, before starting, his own maps, railway guides, guide-books, and histories, and prepare himself for speaking enough of the language to "get along" alone if need be. No one travels truly who does not travel on his own account, and, from the first, independent travel should be aimed at by all who can hope to speak a little travellers' French.

Tickets. Tickets for the main lines are best taken beforehand through one of the agencies, but nothing is gained by booking a fixed route off the main lines. For example, anyone visiting France along the route Dieppe, Rouen, Lisieux, Caen, Coutances, Dinan, Morlaix, Quimper, Auray, Rennes, Le Mans, Chartres, Paris, and Dieppe, would get all the cheapness possible by taking a return ticket to Paris, and not using the outward section between Rouen and Paris. All the rest of the journey is simply the ordinary fare, and by not booking beforehand the traveller retains his freedom of movement.

Routes. In planning a travel-tour, the inexperienced traveller should avoid, above all things, the conceit of getting "off the beaten tracks." The tracks which are beaten are the best tracks. That is why they are "beaten." He sees there what is finest, and sees it easily.

As regards expenses, hotel charges have increased greatly in recent years, and no guide-book can be trusted, but *pension* charges are still reasonable, and the food and accommodation at good *pensions* compare favourably with the hotels which charge twice the *pension* prices.

England and Wales. A good deal may be said for travel in the British Islands before the Continent is visited extensively. By touring at home, much advantage, similar to that of foreign travel, can be gained. People who go year by year to one holiday resort are wasting many chances of experience, and may form habits of restfulness which unfit them for seeing any other place properly. Only the rambler learns how to know a district, whether he rambles on foot—much the best way—or by cycle, or by motor-car.

None can claim to know the British Islands adequately who has not *walked* the English Lake District, both through the passes and over the "tops," from Skiddaw to Coniston Old Man, and from Mardale to Wasdale; explored North Wales from Conway to Barmouth, peak by peak and stream by stream; traced the lovely valleys of the Upper and Lower Wye; followed the coast of Devonshire and the hinterland moors from Minehead to Ilfracombe; glanced at Clovelly, and tramped the Cornish coast past Hartland, Bude, Boscastle, and Tintagel to Padstow, Bedruthan, and Newquay; explored the Land's End region from St. Ives round to Penzance and the Lizard; sampled the wooded rivers of the south—the Fal, the Fowey, the Looe, the Tamar, and the Dart; crossed Dartmoor; compared the lovely little "combe" coves by Torquay with the sheltered nooks on the eastern side of the Exe—Budleigh Salterton, Sidmouth, and Bere—and the stern "ledges" of the Dorset coast; surveyed the Great Heath of the Hardy novels

from the Purbeck Hills; known the glades and copses of the New Forest; skirted the Isle of Wight; followed the great back of the North Downs; discovered that Kent is the real Garden of England; sailed on the lazy waters of inland Norfolk; felt the sobering influence of the wide Fenlands from some such ancient capital as Crowland; gazed over all central England from the worn but wooded granite core of Charnwood; tramped the dales and moorlands of Derbyshire and of Yorkshire, west, north, and east; crossed the back of the Pennines from High Teesdale or the Upper Tyne; and studied the historic cities and towns that are England's pride—London, Canterbury, Oxford, Cambridge, Winchester, Salisbury (with Stonehenge), Bath, Stratford-on-Avon, Norwich, Lincoln, York, and Whitby.

Scotland and England. At least an equal charm awaits the wanderer through the parts of Scotland associated with the personal memories of Burns and Scott; the lochs, salt and fresh, and the islands of the outer Clyde region; the still wilder mountain lands and islands northward of Oban; the lovely glens and spacious moors reached by the Highland railways; the incomparable valley of the Dee, leading up to the recesses of the Cairngorms; and the romantically placed centres of Scottish history—Edinburgh, Stirling, and Inverness.

No whit behind, and wearing a quite distinctive beauty, are well-nigh the whole coastal regions of Ireland—the graceful hills and sweet glens of Wicklow; the lovely reaches of the Blackwater; the enchanted route by Bandon and Glengariff to Killarney; the inlets of Kerry; the cliffs of Clare swept by the mighty Atlantic; the lovely sternness of Connemara, changing into the softness of Sligo, and again to the barren heights of Donegal; the noble coastline of Antrim, and the "Mountains of Mourne sweeping down to the sea." Who would linger holiday after holiday in a single seaside resort, when these glories of our islands, so varied in their enthralment, are waiting to delight us, and to offer us travel experiences scarcely to be surpassed by the enchanting foreign lands which beckon all the people of the world?

Belgium and Holland. When we have seen the British Islands reasonably well, or are prepared to alternate holiday rambles in the homelands with holidays abroad, where should we begin our Continental experiences? Many, lured by cheapness, organised travel, and the call of the mountains, go straight to Switzerland—to Lucerne, Grindelwald, Chamonix, or Zermatt. But it is not good management. After Switzerland, almost any other part of Europe is an anti-climax. There one does nothing but absorb, out of doors, scenic impressions; and that habit is almost antagonistic to the mood that should be dominant during the greater part of Continental travel. It is the mood of study—with gladness and lightness of spirit, but still study—that is most fitting; and Switzerland only casts over the senses the glamour of sheer enjoyment. Besides, Switzerland is on the way back from many places that should be seen and studied; and so in Switzerland invigoration may be suitably sought for a few days at a time *after* holidays elsewhere that were educationally remunerative but not physically stimulating.

The most natural and well-graded holiday to begin Continental travel with is a tour of Belgium and Holland. These countries are near, their internal distances are short, and living in Belgium is cheap, so that the total cost is low. The traveller has opportunities of testing his French, though English is fairly well known in the cities. Above all, Belgium is a great vestibule to the mediæval art of Northern Europe. It is not only the vestibule, but the chief court of the temple.

The right route to follow, so as to see the art treasures of Belgium in their proper sequence, is, first, Bruges, then Ghent, then Brussels, and, later, Malines and Antwerp. From Antwerp a tour of Holland may be made for the sake of its picturesque quaintness, the round including Delft, The Hague, Leyden, Haarlem, Amsterdam, and the Zuyder Zee, returning by Utrecht and Dordrecht to Brussels, from which, as a closing complement to the town studies of art and a storied past, a refreshing visit may be paid, by Namur and Dinant, to the romantic woodlands of the Ardennes.

Bruges, Brussels, Antwerp. In no part of Europe is travel more truly educative than in Belgium, if it be thoughtfully prepared for. Bruges is the town which shows best the rise of Flemish culture. It is the oldest and best preserved of the merchant centres which gave to early art and learning patronage and defence. Once it vied with Venice as the home of commerce. Its choicest treasures are its pictures by Memling in the Hospital of St. John, its Notre Dame, its city buildings, its picture gallery, and its quaint old houses. Anyone who cares nothing for the history of art should keep away from Belgium. Ghent is famous for its "Adoration," by the Van Eycks, in the internally fine Cathedral of St. Bavon, and for its Gothic Hôtel de Ville. Brussels has a wonderful Town Square and a noble cathedral. It also has art galleries which illustrate completely the paintings of the Flemish schools. Malines has a very beautiful cathedral and an air that tones the mind to the past. Antwerp, belonging to a later period than Bruges, is dominated by Rubens. It has a glorious cathedral and a unique eighteenth-century printers' museum—the Plantin-Moretus—which is one of the choicest historical memorials in Europe.

Touring in France. An alternative beginning for Continental travel, competing with Belgium, is a tour in France. The best route at first is that already outlined, from Rouen through Normandy and Brittany, and back to Paris, with a trip from Rouen down the Seine to Caudebec added during the return journey from Paris. Paris itself is certain to be visited often by those who go abroad, for it is an almost indispensable stopping-place going and returning, as it lies at just the right distance from London for a rest. What the visitor most needs to realise is that Paris is much more than a busy and cheerful modern city. It is a great historical centre, like London, and ministers

to the student as completely as to the fashionable spendthrift. Until historical Paris is known, the true Paris is unknown. The Champs Elysées and the shopping streets are no more Paris than Rotten Row and Regent Street are London.

If we group the Chamonix district with Switzerland, the best of France may be seen in three tours. Towns like Amiens and Rheims, on main lines, will fit in suitably, as resting-places, when journeys farther afield are beginning or ending. But Normandy with Brittany, the Loire district and Central France, and the Dauphiné, must be separately visited, each furnishing a full holiday round.

Through Brittany. The features of the north-western tour are the noble cathedrals of Normandy and the intimate associations between the early histories of the Dukedom and the English kingdom. Then, farther westwards, the characteristics of the Breton race, and the curious linking of their religion, finely expressed in mediæval cathedrals, with the earlier Nature-worship of vanished peoples. The cathedrals and abbeys of Rouen, Lisieux, Caen, Bayeux, Coutances, Mont St. Michel, Dol, Quimper, Angers, Le Mans, and Chartres make up a round which, architecturally and historically, is unequalled elsewhere. The French railways, too, have the happy peculiarity of arranging midday breaks of three or four hours, which allow the traveller to see one small cathedral town and reach another for the night's rest.

Central France. Another tour from Paris would include Orleans, Blois, Tours, Saumur, Poitiers, Angoulême, Limoges, Perigueux, Brive, Aurillac, Clermont, Nevers, and Bourges, thus combining the cathedrals and castles of Central France with the interesting volcanic mountains of the Auvergne. The ideal ending to this route, were it not somewhat long, would be to continue from Clermont-Ferrand southward to the splendid remains of antiquity at Nîmes, Arles, and Orange and the papal memories of Avignon, finishing with an invigorating visit to the Dauphiné Alps, with Grenoble and Chambéry as centres; or this latter extension may be taken as a separate holiday, with Dijon as a resting-place on the way to or from Paris.

Most of the other inviting districts of France, such as the Vosges, the Jura, the Riviera, and the resorts along the foothills of the Pyrenees, are on, or but a little way aside from, great "through" railways, and may be visited en route, as a change from more studious travel.

Up the Rhine. One of the travel-trips that should be treated as an approach to Switzerland is the little journey up the Rhine between Bonn and Mayence. To return by this route from Switzerland is to deprive the Rhine of all chance of distinction. The dullness of the stream before Cologne and Bonn is needed to prepare the mind for enjoyment of the pleasant scenery which follows, and between Coblentz and Bingen grows romantic. Part of the reputation of the Rhine depends upon the ease with which the river is seen—from the deck of a quiet steamer amply provided with creature comforts.

On the left bank of the Rhine, starting from either Remagen or Andernach, is the Eifel volcanic country, one of the most delightful of the quaint and simple areas of Europe. It richly repays a ten days' ramble. In recent years it has become very well served by hotels at reasonable rates. Before, it was too primitive for the average traveller.

A short railway journey beyond Mayence is Heidelberg; another short stage reaches Strassburg; a third, and we are at Freiburg and the borders of the Black Forest. These cities are all interesting, and the Forest is the most fascinating stretch of woodland in Europe. The popular route is through the Hollenthal to Titisee, and thence southward to the Rhine at Waldshut, but it is impossible to fail to find beauty in this land of blue mountains and woods. On reaching the Rhine, Schaffhausen (with the Falls of the Rhine) and Basle are close by on either hand; and this gentle holiday, with the Rhine as a guiding line, may be fitly closed at Lucerne, where the greater mountains are approached, and the upper snow-world becomes a presence in the distance.

The Quality of Swiss Scenery. So we have reached Switzerland, the bourne of all who travel to enjoy natural beauty. Unquestionably Switzerland is the most attractive country in the world, judged by grandeur, loveliness, and accessibility. Its only close competitor is Tyrol, which has a charm all its own, but lacks the alternations of mountain and lake, and of sweetness with strength. The lakes of Tyrol are only mountain tarns. The lakes of Switzerland brighten some of its broadest landscapes. Both lands have mountains of haunting outline, such as are rare elsewhere. Norway, for example, and the most vaunted parts of the Canadian Rockies have no peaks comparable in distinctive character with the Matterhorn, the Jungfrau, Mont Blanc, Monte Rosa (as seen from the south), and the Weisshorn, in the Western Alps, the Croda Rossa, Antelao, Drei Zinnen, and Ortler Spitz in Tyrol. The finest road-route in Europe is the Stelvio, which climbs to a point where Tyrol, Switzerland, and Italy meet, and so adjusts their rivalries. [See p. 5043.]

Beaten Paths Best. Popular travel has been singularly successful in reaching the finest mountain centres of Switzerland—Lucerne on the northern fringe, Grindelwald and Kandersteg in the centre, Chamonix (France) in the south-west, Zermatt nestling under the great circle of the southern mountain belt, Pontresina towards mid-east. But nobody sees this country as it should be seen who does not leave the railway and cross the chief passes by road, for the Albula and St. Gothard are the only passes that can be said to be superseded, or represented, by their rail routes. The Via Mala, Splugen, and Maloja Passes remain by far the finest route to the Engadine for all who wish to travel instead of merely getting there. The Simplon railway does not in any sense represent the Simplon Pass; and the new short railway cut into the Rhone Valley from the Oberland will never supersede the Gemmi or the

Grimsel Passes with the genuine Nature-lover who is not bound to rush. No one can understand what he sees when he gazes on a great array of mountain outlines until he has conquered lofty heights at a foot's pace, and knows what rocks and glaciers look like both near and far off. It is quite possible that to many an unobservant person who arrives at the Wengern Alp by train, the Eiger, Monk, and Jungfrau are only three white humps just over the way. This type of traveller never knows enough to be impressed.

The effects of travel in Switzerland, apart from stimulation by a health-giving climate, are solely sensuous. They remain only with the passionate lovers of the sublime mountains. But, to such, life in Switzerland is a dream visited by all that is delightful. There is little to study, or that links the present and the past. All the history of the land that is of great importance can be read in half an hour. The present is the most impressive of all periods, particularly from the points of view of industry, education, and defence. In Switzerland we simply enjoy.

The Rival of Switzerland. In many respects, Tyrol, the traditional enemy of Switzerland, is like her. The best way to Tyrol shows the traveller the industrial north of Switzerland—Zürich in particular—then it tunnels from the upper Rhine valley under the Arlberg, and descends to Innsbruck, the most beautifully placed considerable town in Europe. When one has passed beyond Switzerland all roads lead to Innsbruck. Near and far it is surrounded by beautiful districts that need several holidays for a hasty glance. To the north-east is the Austrian lake-district, the Salzkammergut beyond Salzburg, a lovely intermixture of lake and peak and wood; to the north, the romantic highfields of Bavaria have Berchtesgaden to the east and Ober-Ammergau to the west; south-westward lies the Engadine; and southward and south-eastward the abrupt, lightning-riven peaks of the Dolomites, in the midst of which are valley nooks of unsurpassed beauty. A good road from Toblach via Cortina to Campitello, Karer See, and Botzen now opens up the centre of this formerly inaccessible region. Southward from Innsbruck the Brenner Pass, the "German road" of the Romans, passes into Italy to Verona, while farther to the west the way out from the mountain-hemmed Tyrol is over the stupendous Stelvio, a summer route which climbs to more than 9000 feet. This beautiful country competes with Switzerland for the admiration of the lover of fine scenery. The southern slopes of the Tyrolean mountains, by the way, are Italian, and formed a friendly hinterland for Venice in the days of her greatness.

Some German Centres. The rural parts of Germany beyond the region of the Rhine that are attractive to visitors are the Hartz Mountains, between the middle courses of the Rivers Weser and Saale, and the Thüringen Forest, around the sources of those rivers. German cities that ought to be visited are Dresden, for its art treasures, and Munich, for its art treasures and modern institutions, but, above all, Nuremberg, one of the three or four European cities which retain a mediæval atmosphere in so large a measure as to impress the least receptive. Of the Germanic capitals, Berlin and Vienna, the first is a large, obtrusive place, showy and aggressive, with no distinction; the second is much finer, whether regarded from a historical point of view or as a repository of the products of human taste and knowledge.

Italian Scenery. Italy, of course, is the final goal of all who travel that they may know and feel. The scenic attractions of this fascinating land are great, from the Alps, whose summits make the frontier, and whose steepest sides often fall into Italy, and from the sweetly sheltered lakes which hold back the Alpine waters from the Italian plain, down to the fruit-garlanded coves of the rocky Italian Riviera, the gloriously green landscapes of the Tuscan valleys, and on to the wildly romantic precipices of the Amalfi coast in the south. But the real call to the traveller comes from the Italian past. Nowhere else is the sense of time and of human change so impressively aroused.

The Pageant of History. Rome, Florence, Venice—there you have the story of two thousand years made clear, between the old Empires of the East and our modern history.

Rome must begin the tale. The traveller who looks around him in Rome with any clearness of vision must see signs of at least seven epochs—first, the simplicity of Republican Rome from which all Roman virtues sprang; second, the magnificence of imperial Rome; third, the struggling emergence of Christianity; fourth, the chaos following barbaric destruction; fifth, the great revival of Christian art that came to Rome, largely from Florence; sixth, an age of neglect of the treasures of antiquity; seventh, the modern period of business energy, accompanied by a wise care for the past. In Florence, the glorious home of Italian artistic genius, one phase of this evolution is impressively seen, and in Venice another. Many other Italian towns play their parts, notably Pisa, which commemorates in marble the stemming of the onrush of the Mohammedan hosts across the Mediterranean.

The spoils brought home from Italy by the traveller—the harvests of the mind and heart, that is—are richer than those from elsewhere, because they combine much from Nature, since the land is beautiful; even more from art, for here was a direct inheritance from the art of Greece and a reflowering, in painting, into a loveliness the Greeks never knew; and withal there is an abundant ministration in Italian scenes to historical perception, serious thought, and religious impulse.

In the Mediterranean. Travel in other lands must be referred to even more compendiously. There are now many opportunities of visiting various parts of the Mediterranean where our civilisation was in a large degree evolved. The islanded shores of the Adriatic, so long held back from prosperity by turbulence

inland, can be traced to the sunny isles of Greece; but, except to the expert classical scholar, Greece, even from its very heart in Athens, does not exercise the influence over the imagination which exhales, as it were, from Rome. The reign of tangible power in the case of Greece was too short—a mere flash—though the influence of the Greek mind is everlasting. As with Palestine, so with Greece: the sights of today give but little help to the reverence that would interpret the glorious past.

The Birthplace of Civilisation. The only country within holiday reach, except Italy, that preserves adequately a feeling of a vanished civilisation is Egypt, but the Egyptian civilisation, though powerfully suggested by the ruins which have been so industriously uncovered, is alien to Western feeling in comparison with that of Rome. Many shrink from examining with care the deeper layer of history; and to the average traveller Egypt is primarily a land of a delightfully equable climate, refreshing to the jaded, and offering the air of the desert like a precious vintage. This practical view of Egypt shows the good sense of the average traveller; for while the world owes an incalculable debt to the masters of Egyptology, the travellers who have but a little knowledge of it are among the worst of travelled pests.

THE WINDINGS OF THE FORTH NEAR STIRLING

Unknown Spain. Spain is a country that cannot yet be truly seen by the casual traveller. A journey to the Pyrenean borders of Spain is delightful on the French side, and San Sebastian, just over the frontier, bids high for a first place among seaside resorts that are glorious for situation; but a journey by rail through Spain to Burgos, Madrid, Toledo, Cordova, Grenada, Seville—the usual route—only gives an absurdly casual impression of the country, for the traveller is surrounded all the while by international, and not Spanish, conditions. Such a journey through Spain is almost as artificial as a ride on a switchback railway at a fair. The truth is that Spanish food and accommodation debar the traveller from seeing the country as it is unless he will "rough it." So it is glanced at from a window in the most comfortable season, and the Moorish past is studied with interest, while the present is a sealed book.

The Northern Capitals. A sea journey that is very popular, and may be thoroughly recommended, is the round of the Northern capitals. This usually includes a call at the pleasantly situated city of Christiania; at Copenhagen, where the politeness and charm of the people hide the fact that popular sights are few; Stockholm, a city strewn in a forest beside many waters, and possessing a fine museum of national historic life; and then Petrograd, with a visit to Moscow. Of all travel in Europe outside the unsettled parts of the Balkan Peninsula, this experience of Russia is the freshest and most stimulating to the average British holiday-maker. Everything in Russia is strange, unexpected, delightful. The riches of Russian art treasures, as at the Hermitage in Petrograd, the magnificence of the cathedrals, the musical sonority of the worship, the religious sentiment of the people, their simple, kindly ways, the touch of Eastern colour, the feeling of being hemmed in between an almost barbaric splendour in religion and specialised wealth on the one hand, and a colossal commonplace in the kindly masses on the other hand—these and all other impressions are curious, new, unlooked-for, stimulating, and the effect of a Russian holiday is a fresh start to one's interest in life.

Sombre Norway. Some mention should be made of Norway—the easiest land to visit wholly by sea. The influence of Norway is precisely similar to that of Switzerland; that is, it is an interviewing of Nature in a fresh form. But Norway is sombre—always a little sombre. The long winter nights have settled upon the hearts of the people and made them quiet, almost inert, though very kind. Every voyager to Norway should make a point of going as far north as the Romsdal Fiord, as far south as Bukken Fiord, and of taking at least one land excursion. From Odda to Sand is perhaps the best.

The Peopled Mind. With all these travel-scenes awaiting us, at home and abroad, is it not strange that so many are content to see the same place again and again when the time for a holiday comes round? They have not realised that there is nothing so recreative as a *complete* change; that new scenes and ideas restore us mentally as well as stimulate us physically: and, further, that well-planned travel leaves with us a vast fund of impressions that will supply the mind with material long after travel may have become a burden.

JOHN DERRY.

TRAVEL CONCLUDED—END OF GROUP 2

The Work of Organising British Agriculture. Co-operative Societies and their Objects. The Province of the Board of Agriculture.

CO-OPERATION IN AGRICULTURE

Among the many advances which will always make the nineteenth century notable in history, the co-operative movement may claim a high place, and, being mainly an achievement of the working classes, it is bound to influence profoundly all democratic communities. Co-operation essentially consists in the substitution of "mutual aid" for selfish competition, and in our own country its inception was due to the energy and ability of Robert Owen, whose ideas crystallised into actions in 1821, but the great successes of the movement fall within the last sixty or seventy years. Although the early co-operators included agriculture in their purview, and regarded "community in land" as their goal, other forms of industry were the first to be organised; and it appears to be reserved for this generation to revolutionise agriculture, still "the first and most important industry," by the thorough application of co-operative methods. Some of these we will briefly consider.

The Organisation of Agriculture. It must be emphasised that the interests of *all* classes concerned with the land can be furthered by co-operation, but the best results cannot be expected until mutual trust replaces mutual distrust, the latter being furthered and fomented by our hateful system of party politics.

Agricultural co-operation did great things in such countries as Denmark, France, and Germany before this slow-moving nation perceived its possibilities. The extraordinary prosperity of Denmark, our most serious rival in the dairying and poultry industries, is almost entirely due to the adoption of thorough-going co-operative methods, associated with a genuine system of education (not "cram") sadly to seek in Britain. Sir Horace Plunkett and Father Finlay, students of Continental methods in the 'eighties, founded the Irish Agriculture Organisation Society (I.A.O.S.) in 1889, and this has done far more to make Ireland prosperous than many generations of politicians. The English Agricultural Organisation Society (A.O.S.), founded in 1901, has been forwarding the movement with great success in England and Wales, and the Scottish Agricultural Organisation Society (S.A.O.S.) was founded in 1905. Information and counsel are enthusiastically given by the secretaries of these societies, the respective addresses being—Plunkett House, Dublin; Queen Anne's Chambers, Tothill Street, Westminster, London, S.W.; and 5, St. Andrew's Square, Edinburgh.

A brief survey of the aims and objects of the A.O.S. will give some ideas as to the possibilities of agricultural co-operation.

The Idea of Co-operation. The bed-rock idea of the whole thing is based on the commonplace that men in a large way of business can buy, sell, or borrow on better terms than those whose transactions are on a small scale. From this it follows that a co-operative society of the latter, by trading jointly, is able to secure the best possible terms; and the small-holding movement is bound to fail, except in particular cases, unless this principle is followed.

Aims of the Agricultural Organisation Society. The A.O.S. is controlled by governors whose names inspire complete confidence, and it "exists for the purpose of advocating the principles of co-operation among agriculturalists, and of giving advice and assistance in the formation and organisation of properly registered co-operative agricultural societies in suitable districts throughout England and Wales," these being "entirely self-supporting and self-governed." "The A.O.S. does no trade and makes no profits," a most important statement, for the movement is purely patriotic, and presumably, therefore, no governor has "an axe to grind."

Purchase of Seeds and Implements. The objects of the local Agricultural Co-operative Societies are: *Object A:* "To purchase for their members (1) manures, seeds, feeding stuffs, implements, and the like, on wholesale terms from the manufacturers, importers, or wholesale merchants, a small profit being charged to cover management expenses; (2) to attempt to secure the purity of feeding stuffs, seeds, and manures, the guarantees for which are often misleading or insufficient for the information of the purchaser. Co-operative societies are better able to protect their members in their purchases, for even when the proper guarantees are given, farmers, as individuals, rarely have analyses made."

It must be distinctly understood that a co-operative society differs entirely from a joint-stock company, such as one of the West End London "stores," though these may be called "co-operative" in another sense. But a joint-stock company divides its profits among a limited number of shareholders, while the profits of a genuinely co-operative society are shared by the purchasers, who, in our case, are the farmers, small-holders, and so on, constituting the company.

Picking a case at random from the 1914 report of the A.O.S., we find that during 1913 the West Midland Farmers' Association, with a membership of 419, expended £61,947; and it is quite clear that the 419 members were able to get much better terms, purchasing collectively, than if each man had made his own purchases.

In certain cases a large society can, by forethought, escape from the loss entailed by rise in price of a popular article. A particular and deservedly popular make of binder twine (for use in the reaper-and-binder machine) was so much in demand that its price went up in a marked way. One of the larger societies went to another firm of twine manufacturers, and by ordering some tons in advance was able to secure an equally desirable article at a normal price.

The endeavour of co-operative societies to secure pure feeding stuffs, seeds, and manures is of the utmost practical importance, preventing large waste of money in the actual outlay and promoting good results in crop and stock production. Farming is so complex a business, and profits have been so cut down by colonial and foreign competition, that the business principles regulating other forms of

industry ought to be adopted. One such principle is the division of labour, the share of the farmer in that division being to make the most of his land for productive purposes; and here the British farmer is second to none. He can no doubt judge the value of feeding stuffs, seeds, and manures to a certain extent, but this can only be done in detail by other experts, and these are employed by his co-operative society to ensure that he gets what he pays for, and to protect him against the unjust adulterator who will be a permanent fixture so long as poor human nature remains what it is.

Milk Supplies. *Object B:* "To secure the best market for the sale of produce. (1) By organising the milk supply on a co-operative basis, so that a large proportion of the profits may be secured for the farmers."

Here, as generally, it is a question of eliminating the middlemen who absorb so large a proportion of the profits of agriculture, the aim being for milk to go direct from the producer to the consumer. Considering that various societies have succeeded in securing for their members an advance of from one farthing to a penny per gallon for whole milk, this particular direction of activity would appear to be well worth while.

Butter and Cheese Factories. (2) "By establishing co-operative butter and cheese factories in suitable districts."

The production, at a profit, of butter or cheese by the individual farmer is commonly out of the question, for it is highly skilled work, requiring special facilities. The co-operative factory, operating on a comparatively large scale, is able to buy milk from the farmer for what it may be worth, making from it products of uniform good quality. This is the secret of the Danish success in dairying, for the consumer wants uniform good quality, and gets it every time. Co-operative dairying has proved a conspicuous success in Ireland, and has proved its value in certain parts of Great Britain, where it is advancing steadily.

Egg and Poultry Depots. (3) "By establishing co-operative egg and poultry depots for sorting, grading, and packing."

Not so very long ago the "Irish egg" was proverbial for its doubtful qualities, and the trade was in the hands of middlemen, who collected eggs in a very unsystematic manner, and but little to the benefit of the producer. Co-operation has changed all this, for Irish eggs are now on the English market, properly sorted, graded, and packed, within three days of being laid, and the profits go to the producer. Similar methods are gradually being established in various parts of Great Britain, although progress is not very rapid.

Fruit Packing and Grading. (4) "By grading and packing fruit, in order to place it on the market in a fresh and attractive condition."

Our great fruit-growing areas are beginning to realise that increased profits result from proper grading and packing; and where this is done on co-operative lines, the profits, of course, belong to the growers. Attention is also being paid to the making of chip baskets and other receptacles for fruit.

Sale of Wool. (5) "By organising the disposal of wool, so that sheep-growers may have it properly classed and packed, and so secure good prices from the wool merchants."

This is a new and promising direction of activity, and the advantages are comparable to those given under preceding headings.

Bacon Factories and Pig Sales. (6) "By organising the bacon and pig industries for the benefit of the producers."

Efforts have been so far directed to the disposal of live pigs, the pioneer co-operative society being that of the Eastern Counties Farmers. In 1905 this society dealt with 5681 pigs, value £17,400; in 1913 with 23,082 pigs, value £120,938. Co-operative bacon factories may be expected to follow later.

Markets and Transport. (7) "By organising co-operative markets, to reduce the cost of disposal, and to break down the rings formed against the producer."

This important aim yet remains to be realised.

(8) "To reduce the cost of transport, by bulking consignments and by arranging terms with railway companies and carriers."

Co-operation on these lines is of obvious utility. A railway company, for example, will naturally give favourable terms when large consignments are in question.

Object C: "To open up remote districts by motor traction."

Comparatively little has so far been done in this direction, but in course of time there can be no doubt that motors will so supplement railways that all farmers will have a fair chance of selling their produce to advantage, and will thereby be stimulated to increase their output. Eggs and other products of considerable value in proportion to their bulk are particularly adapted for conveyance by motor; and it is sufficiently clear that co-operative methods are the only ones that can give the best results.

Stock-breeding. *Object D:* "To hire or buy pedigree stallions, bulls, etc., for the use of their members at reasonable rates."

Fortunately, this matter is now actively being taken up by the State, for the Board of Agriculture, aided by advances from the Development Fund, has initiated a Live Stock Improvement Scheme, from which great things are expected. The scheme is especially intended to benefit small farmers and small-holders, many of whom have in the past hardly realised the great importance of "quality" in stock.

Insurance. *Object E:* "To arrange for all kinds of agricultural insurance."

Increasingly useful work is being done by the Agricultural and General Co-operative Insurance Society; and "smaller local insurance societies or 'clubs' enable their members to insure economically their horses, cows, and pigs, by co-operating with one another."

Letting of Land. *Object F:* "To acquire land and sublet it to members in small holdings or allotments."

A number of societies have been formed to work under the Small Holdings and Allotments Act (1908), but here again the Board of Agriculture has shown considerable activity, and the special local work has been undertaken by county officers. Small holdings, at least those of agricultural nature, are pretty certain to be a dismal failure unless they can be grouped and managed on co-operative lines, each such group being controlled by a representative committee. It is only in this way that buying and selling can be conducted to advantage, the more expensive agricultural machinery employed, the dreary country winter enlivened, and the children of the small-holders secure the chance of suitable education.

Credit Societies. *Object G:* "To establish Agricultural Credit Societies."

Larger men can easily obtain money advances, while smaller cultivators, who need such advances more, are unable to do so. In other words, Land Banks, on the lines of the Raiffeisen and Schulze-Delitsch Banks established in Prussia about the middle of last century, are a crying necessity, although a number of the more reputable ordinary banks are willing to act in this capacity. The small farmer or small-holder ought, for example, to be able to secure at a reasonable rate the money necessary for the production of a crop, offering as security the value of that crop when harvested. We hear no more of dire distress among small cultivators in the West of Ireland, and this is because pecuniary advances have been rendered available on the lines indicated. Help on sound business lines, not charity, is what is needed.

Work of the Board of Agriculture. Quite apart from the co-operative societies, there are many organisations which exist solely to help the farmer, and some of these will now be passed in review. Readers wishing for further details will do well to consult the "British Year-book of Agriculture" (Vinton & Co., 5s. net), which is a perfect mine of information.

The Board of Agriculture was established in 1889, taking over various duties until then performed by other departments. It is now also responsible for Fisheries, the Ordnance Survey, and the Royal Botanic Gardens at Kew, but with these activities we are, of course, not concerned in this article. To Sir Thomas Elliott, Permanent Secretary from 1892 to 1913, agriculture owes a large debt of gratitude, and his pioneer work has been the making of the Board. Four branches or divisions of the Board have to do with agriculture.

The Animals Division. This is concerned with certain notifiable diseases of animals, and by an elaborate official machinery keeps them more or less in control.

The Intelligence Division. This branch administers the Acts dealing with the sale of food and drugs, fertilisers and feeding stuffs, destructive insects and pests, and so on, and also plays an important part in furthering education and research in agriculture and forestry. It publishes a valuable monthly journal at a cheap rate, and also a series of important leaflets on a great variety of subjects. Anyone interested in agriculture can, by sending a shilling to the Secretary of the Board (Whitehall Place, S.W.), secure the first 200 leaflets bound in two volumes, and subsequent leaflets gratis, and can enter his name on the list of those who receive, also gratis, further issues. Postage need not be prepaid, so that at no expense, except the initial shilling, those who will may greatly benefit. Advice on all agricultural matters is freely given.

The Land Division. This is mainly concerned with small holdings and allotments, and with the new Live Stock Improvement Scheme, under which work provincial live-stock officers, whose duty is to help farmers, especially small farmers, in every possible way.

The Statistical, Tithe, Commons, and Establishment Division. This branch collects and publishes a variety of important returns.

Similar duties are performed by the Board of Agriculture for Scotland and the Department of Agriculture and Technical Instruction for Ireland.

Provincial Schemes. An average English county maintains an expert staff, working under an agricultural organiser, and engaged in conducting classes for those on the land, and also in giving advice on routine matters. Arrangements are usually made whereby farmers can have analyses made of feeding stuffs, artificial manures, etc., at low prices. Some countries possess a farm institute or farm school for the benefit of those who are able to leave home for the purposes of receiving continuous instruction. England and Wales are now divided into twelve provinces, each with a Provincial Council for Agricultural Education, which correlates the activities of a group of counties, and is entrusted with directing—aided by a live-stock adviser—the Live Stock Improvement Scheme for its particular area. Each of the twelve provinces has a "collegiate centre," responsible for the higher forms of instruction, the giving of advice on difficult points, and the conduct of research. There are also certain institutions, notably the Rothamsted and Woburn Experimental Stations, which are engaged in research only, and have no local ties.

Scotland is divided into three provinces, for which Edinburgh, Glasgow, and Aberdeen Agricultural Colleges (and University Agricultural Departments) serve as centres, while Irish agriculture is organised by the central authority in Dublin.

Agricultural Societies and Institutions. These are exceedingly numerous, and promote a great variety of objects, many of local character. Three societies with wide aims, which hold important shows and give great advantages to their members by way of providing analyses and technical advice at a cheap rate, deserve special mention:

Bath and West and Southern Counties Society. Founded 1777. (Offices, 3, Pierrepont Street, Bath.)

Highland and Agricultural Society of Scotland. Founded 1784. (Offices, 3, George IV. Bridge, Edinburgh.)

Royal Agricultural Society of England. Founded 1838. (Offices, 16, Bedford Square, London, W.C.)

The Central and Associated Chambers of Agriculture. Founded 1865. (Offices, 1, Orchard Street, Westminster, S.W.)

The National Farmers' Union, founded 1908 (offices, 3, Wellington Street, Strand, London), endeavours "To combine the various Farmers' Unions in the country, with a view to the furtherance of the interests of farmers in a national sense." Only farmers in actual practice are admitted as members—a policy of somewhat doubtful wisdom.

We may fitly conclude this section by mentioning the Farmers' Club (2, Whitehall Court, London, S.W.), founded 1842, which not only provides a convenient centre for those connected with agriculture, but also has monthly meetings during the winter for the discussion of important agricultural questions.

Enough has now been said to indicate the possibilities embodied in agricultural co-operation. The whole thing is pithily summarised in the words of Mr. Nugent Harris, the eminently capable and inspiringly enthusiastic general secretary of the A.O.S.: "Our farmers must organise; there lies the future of English agriculture." J. R. AINSWORTH-DAVIS

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If anybody would make me the greatest king that ever lived, with palaces and gardens, and fine dinners, and wines and coaches, and beautiful clothes, and hundreds of servants, on condition that I would not read books, I would not be a king—I would rather be a poor man in a garret with plenty of books than a king who did not love reading.

LORD MACAULAY

KNOWLEDGE grows from more to more, and the library of the busy man, however he may love books and buy them, cannot keep pace with it. Again and again we find ourselves wondering if there is a book on this subject or on that, and, if so, how we can get it. This supplement to the SELF-EDUCATOR is an attempt to meet this need.

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IF it were possible to produce a work of this kind slowly, and with no regard for the cost of it, it would be possible to produce a work of which an editor might well be proud; but even a book, the greatest monument of human achievement on the earth, must be a commercial thing, and it has been found impossible here to be precise and definite on all points. It is not possible, for example, to indicate in all cases whether prices are net or not, and the prices are given here without this indication, on the ground that it is worth while indicating *the maximum price*, even though the actual price may be threepence in the shilling less. It is a sound rule to work upon that all books not over a shilling are published net, and that most books on serious subjects are also net, especially most technical books.

IN the few cases where neither publishers nor prices are given here the books are easily available from various sources; in some other cases, as in the Chronology of English Literature, prices are often not mentioned because the mention of the book in the chronology is secondary, the main reference to the work appearing elsewhere in the bibliography. A few out-of-print books have been included in the list because they may be valuable to students, and as a rule these books can be obtained from good libraries, but the general aim has been to confine the list to books that are readily available; and any bookseller can obtain probably ninety-nine books in a hundred in this list from the information contained in these pages.

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Bromide Printing. By Rev. F. C. Lambert. (Hazell.) 1s.
Photo Printing. By Hector Maclean. (Upcott Gill.) 1s.
Platinotype: Its Preparation and Manipulation. By Sir W. de W. Abney and Lionel Clark. (Sampson Low.) 2s. 6d.
Chemistry of Photography. By R. Meldola. (Macmillan.) 6s.
Platinum Toning. By Lionel Clark. (Hazell.) 1s.
Toning Bromides and Lantern Slides. By C. W. Somerville. (Hazell.) 1s.
The Artistic Side of Photography. By A. J. Anderson. (Stanley Paul.) 12s. 6d. net.
Romance of Modern Photography. By C. R. Gibson. (Seeley.) 5s.

PHYSIOLOGY

The Human Mechanism. By Theodore Hough and William T. Sedgwick. Illustrated. Ginn. 8s. 6d.
The physiology of the human body is fully treated in its relation to hygiene, sanitation, and the general regulation of its surroundings. A scientific and practical work.

The Circulation of the Blood. By William Harvey.
This famous work, which revolutionised medical science, was printed in 1628 in Latin; the present translation was made 220 years later.

Lessons in Elementary Physiology. By Thomas H. Huxley. Macmillan. .. .. .. 4s. 6d.
A short, clear, businesslike description of the organs and build and activities of the human body. Surveys the general field of anatomical science, and deals with the main facts of the processes of life.

A Textbook of Physiology. By Sir Michael Foster. Four vols. Macmillan .. .. .. 39s.
A classical work on the structure and functions of the body, by the famous leader of the Cambridge School of Physiology. It covers the entire field, and, though clearly and methodically written, it is rather too large for popular reading, though extremely useful for general reference and study.

Manual of Human Physiology. By Leonard Hill. 496 pages. Illustrated. Arnold .. .. 6s.
Designed to give the general reader some insight into the wonderful complexity of structure and function which, taken together, compose a living man. Technical terms avoided as far as possible.

Principles of Physiology. By J. G. McKendrick. 242 pages. Williams & Norgate .. 1s. net
This popular review of the principles of physiology, by a well-known authority who was lately professor in Glasgow University, is designed for readers with no scientific training.

The Human Body. By Arthur Keith. 256 pages. Williams & Norgate .. .. .. 1s. net
This book, by an eminent member of the Royal College of Surgeons, treats of the history of the human body rather than of its structure and mechanism. The body and its senses are considered in relation to the problem of the antiquity and genealogy of man, and the author summarises our present knowledge.

Comparative Physiology. By Louis Agassiz. English translation by Thomas Wright. Bell .. .. 5s. An epitome of the leading principles of the science of zoology, in popular language, but treated scientifically. Though written in the middle of last century, this book still remains one of the best manuals of the subject.

A Handbook of Physiology. By W. D. Halliburton. Illustrated. John Murray .. .. 15s. net A student's textbook of the very highest quality, by the Professor of Physiology at King's College, London. The work has been tested by time, and its 700 illustration, including coloured plates, give it a double value.

General Physiology of Muscles and Nerves. By J. Rosenthal. 324 pages. Kegan Paul .. 5s. The first connected account of the general structure of muscles and nerves, a subject interesting to the specialist, the man of science, and the general reader of cultivated tastes.

The Natural History of Digestion. By A. L. Gillespie. 427 pages. Illustrated. Walter Scott .. 6s. A description of the general laws governing digestive processes in all living bodies—plants as well as animals. Prefaced by an account of ancient theories of digestion, and closing with an examination of stimulants and foods, the book in its leading chapters discusses every phase of digestion and the action of the digestive organs. Its appeal is made both to the student and the general reader.

The Growth of the Brain. By H. H. Donaldson. 365 pages. Illustrated. Walter Scott 3s. 6d. A scientific work for the parent and the teacher, showing the comparative insignificance of formal education. It is suggested that the powers of the nervous system are all-important to the welfare of the higher animals, and that it is necessary to search out their growth and changes. This the author has attempted.

The Brain and its Functions. By J. Luys. 327 pages. Kegan Paul .. .. 5s. In the first part the writer treats of the anatomy of the brain by new methods of investigation that he discovered. In the second part he deals with the general properties of the nervous elements, the evolution of memory, dreams, the genesis of personality, ideas and sense impressions. The book is thirty-two years old, but worth reading.

Deaf Mutism. By Dr. James Kerr Love. 369 pages. Illustrated. Maclehose .. .. .. 9s. net An important work on deaf-mutes, produced in answer to the need for a careful study of the subject from a medical point of view. Besides discussing fully the origin of the disability in speech and hearing, the work treats of the education of deaf-mutes, and surveys the various systems.

Colour-Blindness and Colour-Perception. By F. W. Edridge-Green. Kegan Paul .. .. 5s. Observations based on the examination of 116 colour-blind persons and numerous recorded cases. A practical book, based on work done for the Board of Trade. Attributes colour-blindness to diminution in the visual range, and gives instances of acquired colour-blindness. About one in five persons, according to the writer, has a diminished perception of colour, men being worse than women.

PRICES OF BOOKS

In all cases the prices in this list are the maximum prices, and in many cases, whether indicated or not, there may be a discount of threepence in the shilling. Almost invariably shilling books, and nearly all technical works, are net.

The Brain as an Organ of Mind. By H. Charlton Bastian. 708 pages. Illustrated. Kegan Paul. 5s. After discussing generally the uses and elements of a nervous system, Dr. Bastian considers the nervous system in invertebrates; then the brain of the vertebrates and intelligence in lower animals; and, lastly, brain and intelligence in man. He mentions that he has sought to embody in one book some details concerning all the roots from which the complex science of mind is derived, in order to show its many-sided origin.

HEALTH

See also under Bacteriology

The Hygiene of Mind. By Sir T. S. Clouston. 284 pages. Illustrated. Methuen .. .. 7s. 6d. net This book aims at giving in popular language some of the most important facts that have been ascertained with regard to the mind, and considers the conclusions from those facts in relation to mental betterment through physiological, psychological, and medical means.

Control of Body and Mind. By Frances Gulick Jewett. 269 pages. Illustrated. Ginn. 2s. 6d. Emphasis is laid on the care and cultivation of the special senses; on the relation of health to efficiency, mental clearness, and memory; on the influence which worry, fear, anger, hope, and joy exert over circulation, respiration, and digestion; on the power which alcohol and narcotics have to damage the nervous system and to destroy character.

Functional Nerve Diseases. By A. T. Schofield. 324 pages. Methuen .. .. 7s. 6d. net Deals with the nervous disorders that are "sweeping over civilised society like a plague." Attributes them to the perpetual hustle and competition of modern life, and regards them as mental phenomena rather than physical. Seeing that the mind takes a large share in the causation of many of these nerve diseases, the author argues that the mind should play a considerable part in their cure.

Responsibility in Mental Disease. By Henry Maudsley. 313 pages. Kegan Paul .. .. .. 5s. Discusses how insane persons differ from sane persons; the insane temperament; kinship between madness and various diseases; the different forms of mental derangement; the law in regard to insanity, and the prevention of insanity. A standard work by a high authority on the subject.

Hygiene of Nerves and Mind in Health and Disease. By August Forel. 343 pages. John Murray. 6s. net As a psychologist, especially in the fields of instinct and hypnotism, Professor Forel has a world-wide reputation. His position as director of a Swiss asylum has given him abundant opportunities for the investigation of mental disease. The results are seen in this work. Dr. Forel hold that hygienic rules whose grounds are not understood may easily do harm. Here he tries to give such a conception of popular hygiene as will enable an intelligent layman, with a fair education, to govern his life so as to avoid diseases as far as possible for himself, his fellow-men, and his offspring.

The Dawn of the Health Age. By Benjamin Moore, M.A., D.Sc. Churchill .. .. .. 3s. 6d. net An admirable and convincing volume, intended to demonstrate the necessity for entirely remodelling the present system of medical service in the interests of the whole community. The author pleads eloquently for the establishment of a national medical service, which, he maintains, is the only satisfactory service for rich and poor alike, both being attacked equally by one set of disease agents.

The Health of the School Child. By W. Leslie Mackenzie. 127 pages. Methuen .. 2s. 6d.
A useful study of what may be done through the medical inspection of school children. The experience of the author has been gained in Scotland, and he is also acquainted with German organisation of school inspection from a medical point of view. A most careful sketch of a most hopeful movement.

School Hygiene : the Laws of Health in Relation to School Life. By Arthur Newsholme and W. C. C. Pakes. 310 pages. Illustrated. Allen & Unwin. 3s.
Intended for teachers, school managers, and other persons interested in the health of school children. Deals with the site and surroundings, lighting and ventilating of schools, the diet, dress, physical education of scholars, and has valuable chapters on communicable diseases for the guidance of teachers.

Infancy. By T. N. Kelynack. Methodist Publishing Company .. .. 1s. net
A practical little handbook, by a well-known physician, giving advice to mothers and to those who are in charge of such institutions as schools for mothers, crêches, milk depots, etc. A brief statement of the laws relating to infant life and of the action of municipal bodies is included. The whole is in clear and simple language.

Adolescence. By G. Stanley Hall. Two vols. Appleton .. .. 31s. 6d. net
One of the most significant books of the present age, that has only just begun to reach the consciousness of thinkers and educationists in this country. Dr. Stanley Hall, who has great influence in American education, is the first writer to appreciate adequately the enormous importance of the period of adolescence, and to discuss it in all its phrases, comprising its relations to physiology, anthropology, sociology, sex, crime, religion, and education.

Health and Disease. By Leslie Mackenzie. 252 pages. Williams & Norgate .. .. .. 1s. net
Dr. Leslie Mackenzie, medical member of the Local Government Board for Scotland, discusses a wide range of health subjects, including death rates, infections, antitoxins, immunity, tuberculosis, plague, disease and destitution, the evolution of the health movement. Able, popular, and concise.

The Problem of Age, Growth, and Disease. By Charles Minot. 280 pages. John Murray. 6s. net
This book is based on lectures delivered at the Lowell Institute in 1907. It traces life through all its stages, from its inception to its apparent individual disappearance. Dr. Minot belongs to the school of scientists who hold that an agnostic position is the only possible and defensible one for a man who is loyal to the spirit of research, but he does not give the grounds for taking up this position. The work is of great but controversial interest. For example, the author ventures on the most astonishing statement that "few men after twenty-five are able to learn much."

Handbook of Practical Hygiene. By D. H. Bergey. 164 pages. Williams & Norgate .. 6s. 6d. net
A most convenient handbook for the guidance of students in the sanitary analysis of air, water, soil, and the principal food materials, and in testing the ventilation of buildings.

A Manual of Pathology. By Sidney Martin. Illustrated. John Murray .. .. .. 15s. net
A comprehensive survey of the science of general pathology, illustrated with micro-photographs, which has been declared "superior to any other work of the kind in the English language." Intended for students.

The New Hygiene. By Elie Metchnikoff. 104 pages. Heinemann .. .. 2s. 6d.
Three lectures delivered under the auspices of the Royal Institute of Public Health, with introduction by Sir E. Ray Lankester. They deal with the prevention of infectious diseases.

The Care of the Body. By F. Cavanagh. 292 pages. Methuen .. .. 7s. 6d. net
A discussion of the general principles and daily practice of health. Deals with length and conditions of sleep, cold and warm baths, exercise, fatigue and massage, the clothing, skin, hair, teeth, eyesight, and habits. A clearly written book on commonsense ways of life.

The Chemistry of Life and Health. By C. W. Kimmins. Illustrated. Methuen .. 2s. 6d.
This book is intended to give a concise and simple account of the various scientific laws and processes necessary to the proper understanding of the subject of hygiene. In it are described the chemical processes which affect the atmosphere; the structure of the body; the composition of water and of food substances. Ventilation, prevention of infection and of disease, and the proper cooking of food, are treated on a scientific basis.

Infection and Immunity. By George M. Sternberg. 293 pages. John Murray .. .. 6s. net
An attempt to study the main facts with reference to infection and immunity, with the practical object of indicating the measures necessary for the prevention of infectious diseases. The work is intended for non-medical readers, and technical terms are, as far as possible, avoided. Dr. Sternberg confines himself to what he regards as well-established facts, and does not enter upon questions raised by such remedies as "antitoxins" and German chemical specifics.

Sleep. By Marie de Manaceine. 341 pages. Illustrated. Walter Scott .. .. .. 3s. 6d.
A valuable consideration of the "physiology, pathology, hygiene, and psychology" of sleep, with a good bibliography, and interesting examples of dreams and complex personality.

Sleep and Sleeplessness. By Haydn Brown. 160 pages. Hutchinson .. .. .. 2s. 6d.
Very important advice on a little understood subject, to sufferers from insomnia. Will be extremely helpful in all such cases.

Milk and the Public Health. By W. G. Savage. 594 pages. Illustrated. Macmillan .. 10s. net
An attempt to measure and assess the dangers of milk, and show how they can either be removed or diminished. Deals with bacteriology of milk and human disease; the examination of milk, and public health control of the milk supply; education of the milk trade by the rejection of dirty milk; and the necessity for continual bacteriological examinations, because nothing can take their place.

Drugs and the Drug Habit. By H. Saintsbury. 307 pages. Illustrated. Methuen .. 7s. 6d. net
An eminent London physician discourses of drugs in their normal or medical use, and again in their habitual abuse by victims of unhealthy habits. Interesting and readable for those whom the subject attracts; specially valuable to medical students.

Pasteur and After Pasteur. By Stephen Paget. Black .. .. 3s. 6d. net
An outline of the life of Pasteur, with descriptions of the many means for the prevention and expulsion of disease which have been developed out of Pasteur's work. Statistics are given that should be known to all anti-vaccinationists.

Food and the Principles of Dietetics. By Robert Hutchison. 635 pages. Illustrated. Arnold. 16s. net
Designed for students and doctors, but likely to be interesting to any person desiring to acquire some knowledge of foods and the difficult problems of nutrition. Patent and proprietary foods are examined and discussed on their merits, and certain dietetic cures and systems are criticised. Written on the whole in plain English; a work of authority.

Air and Health. By R. C. Macfie. 340 pages. Methuen .. .. 7s. 6d. net
An able work, dealing with the physical and chemical properties of air, particularly with reference to health and disease. The physiology of respiration is considered in its practical bearings, and chapters are devoted to the questions of climate, dust, fogs, germs, epidemics, etc. The discussion of ventilation is interesting.

Alcohol and the Human Body. By Sir Victor Horsley and Mary D. Sturge. Macmillan .. .. 1s. net
A wonderful little book, constituting an armoury of unchallengeable facts as to the effects of alcohol on health. There is a chapter by Dr. Arthur Newsholme, Chief Medical Officer of the Local Government Board, dealing with the influence of alcohol on the national health. A book for all who wish to know the real truth about alcohol.

Alcoholism: a Chapter in Social Pathology. By W. C. Sullivan, M.D. Nisbet. ... ... 3s. 6d. net
Gives in a clear, concise form a summary of the main facts of the drink question, especially in regard to the connection of alcoholism with industrial conditions. Traces a fifth of the suicides of the country to constant intemperance, and three-fifths of the homicidal crime to the same cause. Holds that chronic intoxication is not due to convivial drinking, but to the use of alcohol as a stimulant to muscular work.

The Drink Problem of Today. Edited by T. N. Kelynack. 300 pages. Methuen .. 7s. 6d. net
A survey of the main problems of modern life from many points of view. All the writers speak with authority. Many points of interest are raised, and the individual contributors have not hesitated to express their views on matters on which a disagreement of opinion exists; but, throughout, a truly scientific presentation of the subject is attained.

The Conquest of Consumption. By A. Latham and C. H. Garland. 159 pages. Fisher Unwin. 1s. net
A résumé of the knowledge we have of the cause and prevention of consumption, with a sketch of a national scheme for preventing the spread of the malady, and providing anti-tuberculosis dispensaries. The only adequate remedy for consumption, in the view of the authors, is efficient sanitorium treatment.

Prevention of Tuberculosis. By Arthur Newsholme. 429 pages. Illustrated. Methuen .. 10s. 6d. net
A thorough study of the whole subject, with good bibliography. Its three parts deal respectively with the causation of tuberculosis; the means by which the mortality from this disease has already been reduced; and future preventive measures for the reduction and annihilation of tuberculosis.

The Alcohol Factor. By George Blaiklock. P. S. King .. .. 1s. net
Written for the National Temperance League, this publication deals with alcohol first in relation to the child, then to adolescents, and lastly to adults. The evidence is taken largely from reports, and proves alcohol injurious to physical, mental, and moral health, and economic well-being.

The Geographical Distribution of Disease. By Alfred Haviland. George Allen & Unwin.. 15s.
The author thinks he has discovered a close association of certain types of scenery with certain types of disease, and he seeks to point out where certain diseases thrive, and where they do not thrive, and to study the reason why. Thus, rheumatism should avoid valleys, cancer should avoid all clayey soils, and consumption should hide from the prevailing winds. By means of maps and arguments the author develops these views, for the profit of physician and patient alike.

Bacteria and Their Products. By Dr. G. Sims Woodhead. Walter Scott .. .. 3s. 6d.
Gives an account of the main facts of bacteriology, and the life-history of bacteria and allied organisms, with a discussion of the more important theories as to the part played by them in Nature's economy, especially in relation to the commoner fermentative, putrefactive, and disease processes. Diseases discussed include cholera, typhoid fever, tuberculosis, leprosy, anthrax, lockjaw, diphtheria, and hydrophobia. An admirable summary.

AGRICULTURE

Embracing Cultivation of the Earth, Poultry, Live-stock, Dairying, Forestry, Gardening.

The Natural History Section should also be consulted.

Agriculture. By William Somerville. 251 pages. Williams & Norgate .. .. .. 1s. net
An excellent handbook, by the Oxford Professor of Rural Economy, dealing with the formation, properties, and main types of soil; the amelioration of land; the principles of manuring, including all the different kinds of fertilisers; the rotation of crops, and seed. Bibliography.

Agriculture for Beginners. By C. W. Burkett, F. L. Stevens, and D. H. Hill. Ginn .. 3s. 6d.
The authors of this book believe in training children from an early age to love and understand the fundamental principles of farming. These principles are here presented in a simple and attractive manner, for the purpose of school-teaching of agriculture.

A First Book of Forestry. By Filbert Roth. 291 pages. Illustrated. Ginn .. .. 3s. 6d.
An attempt is being made in America to make the principles of forestry more widely understood in schools and country homes, and this book, by the Chief of the United States Division of Forestry, is well designed for this purpose.

Forestry for Woodmen. By C. O. Hanson. 222 pages. Illustrated. Clarendon Press. 5s. net
A thoroughly practical book on a much neglected subject. Mr. Hanson has a full knowledge of woodcraft. Taking Schlich's "Manual of Forestry" as his basis, he has produced a book which covers scientically the whole range of the woodman's work, in language easy to understand.

A Textbook of Agricultural Botany. By F. V. Theobald. 536 pages. Illustrated. Blackwood. 7s. 6d.
Written for students in agricultural colleges, and farmers. It considers primarily the life histories and habits of animals met with in farm and garden, particularly those which affect, for good or evil, the stock and crops of the cultivator of the soil.

Agricultural Geology. By J. E. Marr. 318 pages. Illustrated. Maps. Methuen .. .. .. 6s.
Prepared for students' reading for examinations in agriculture; but, in spite of its scholastic tone, interesting to anyone who loves the country-side.

Agricultural Zoology. By J. Ritzema Bos. Translated by J. R. Ainsworth-Davis. 312 pages. Illustrated. Methuen .. .. 3s. 6d.
Clear descriptions, well illustrated, of the members of the animal kingdom which are harmful or helpful to the farmer, with suggestions as to methods for getting rid of his foes. The book is intended for use in agricultural colleges, and also for the private use of the practical farmer.

Soil Fertility and Fertilisers. By J. E. Halligan. 397 pages. Illustrated. Williams & Norgate. 14s. 6d.
This treatise on fertilisers of all kinds is intended for the use of farmers, agricultural and horticultural students, manufacturers, and others. The language is as free from technical terms as it was possible to make it. Fertiliser formulas for various crops are given. A book of reference for the practical farmer and student rather than a book to read.

Our British Trees, and How to Know Them. By F. G. Heath. 492 pages. Illus. Hutchinson. 5s. net
An admirable pocket-manual, enabling the observer to identify all species. There are 250 excellent illustrations, chiefly from photographs.

The Principles of Horticulture. By Wilfred Mark Webb. 136 pages. Illustrated. Blackie. 2s. net
Intended to form an introduction to the theoretical side of horticulture, and written primarily for those engaged in its practice, and for the help of students for the Royal Horticultural Society's examination. Annotated diagrams are used to avoid long descriptions, and are admirably clear.

Rural Denmark and Its Lessons. By H. Rider Haggard. 325 pages. Longmans .. 3s. 6d.
An inspiriting examination of the causes of the remarkable prosperity of the small-holders and farmers of Denmark. Two or three far-seeing men managed to induce the Danish peasantry to co-operate in marketing their produce, with the result that they are now one of the most flourishing classes of men in Europe.

Queen-Rearing in England. By F. W. L. Sladen. 56 pages. Illustrated. Houlston .. .. 1s.
A pamphlet dealing with bees, not princesses. It is an excellent practical manual on the breeding of good queens.

Book of Poultry. By Lewis Wright. Revised and edited by S. H. Lewer. Cassell .. 21s. net
This famous standard work has been brought up to date in accordance with the latest poultry club standards. As an authority on the various breeds of fowls, ducks, geese, swans, turkeys, and the best methods of rearing, feeding, exhibiting, and marketing, the book is unequalled.

Our Friend the Horse. By F. T. Barton. 276 pages. Illustrated. Dean .. .. 6s.
A practical guide to all breeds of horses, English and foreign ponies, asses, and mules; to the anatomy of the horse; to conformation; teeth and age; stables and stable-management; foods and feeding; horsemanship and horse-training; diseases, castration, treatment in sickness, and to the buying and selling of horses. The whole is written in a clear, brief, and systematic style, very convenient for reference.

Plant Diseases. By Werner F. Bruck. English translation by J. R. Ainsworth-Davis. 152 pages. Illustrated. Blackie .. .. .. 2s. net
This excellent little treatise is of great practical use. It is distinguised from most other books on the same subject in that it treats chiefly of the effects upon the plant rather than of the character and life histories of pests.

Story of a Grain of Wheat. By W. C. Edgar. 195 pages. Illus. Hodder & Stoughton. 1s. net
A popular account of the wheat-berry and wheat-growing, especially of the great Canadian wheat-fields and their apparently exhaustless sources of food, including also the possibilities in Argentina and in the United States. The wheat-berry itself is analytically described, and the various processes of milling reviewed.

The Book of the Farm. Edited by James Macdonald. 3 vols. Blackwood .. .. 63s. net
A standard work, dealing exhaustively with every branch of agriculture, under the general headings of land and its equipment, farm crops, and live-stock. More than 700 illustrations.

The Food of Some British Wild Birds. By W. E. Collinge. Dulau .. .. 4s. net
An interesting study of the food of birds as shown by the contents of their crops after they have been killed. Farmers, market gardeners, and naturalists are alike concerned in its accusations and apologies. The writer is not too favourable to the birds.

The Development of British Forestry. By A. C. Forbes. Edward Arnold .. .. 10s. 6d. net
A general review of the whole problem of afforestation as it should appear to the landowner and the practical forester. The author holds that a re-adjustment between agriculture and forestry is necessary, and argues his case very cogently. A sound and suggestive book.

The New Earth. By W. S. Harwood. Macmillan. 7s. 6d. net
The sub-title describes this book, with truth, as "a recital of the triumphs of modern agriculture in America." The work done by men of whom Luther Burbank is the type is, as the author says, "of commanding economic importance" in a "tremendously practical realm." The book has a fascination fully commensurate with the importance of its subject, which is the growing, for the use of man, of much more food than could ever be hoped for from the same ground a few generations ago.

Physical Properties of Soil. By Robert Warington. Clarendon Press .. .. 6s.
The contents of this book were first made public in lectures at Oxford, the author being the Professor of Rural Economy. An attempt was made to show how soils have been studied experimentally, chiefly in America, their physical constitution determined largely, and the relations between the soil and water, heat, and the movements of salts examined. An admirable effort to interest cultivators of the soil in the materials they use.

The Fertility of the Soil. By E. J. Russell. Cambridge University Press .. .. .. 1s. net
This book is a reproduction, in the Cambridge Manual Series, of the substance of lecturettes, by the Director of the Rothamsted Experiment Station, on how the soil may be made and kept fertile. An excellent example of scientific lucidity.

The Forester. By John Nisbet. 2 vols. Blackwood .. .. 42s. net
A standard work on British forestry and arboriculture for landlords, land agents and foresters, by an expert scientist and writer. Splendidly illustrated.

The Elements of British Forestry. By John Nisbet. Blackwood .. .. 5s. 6d. net
A practical manual for forest apprentices and students in agricultural colleges and universities, by a highly competent writer. Many illustrations.

Farm and Garden Insects. By W. Somerville. (Macmillan.) 1s.
Text-book of Agricultural Zoology. By F. V. Theobald. (Blackwood.) 8s. 6d.
Diseases of Plants. By H. Marshall Ward. (S.P.C.K.) 2s. 6d.
Diseases of Cultivated Plants and Trees. By G. Massee. (Duckworth.) 7s. 6d.
Small-holder's Handbook. By W. M. Elkington. (Upcott Gill.) 3s. 6d. net.
The Book of the Rothamsted Experiments. By A. D. Hall. (Murray.) 10s. 6d. net.
Co-operation in Agriculture. By G. H. Powell. (Macmillan.) 6s. 6d. net.
Chemistry of the Farm. By R. Warington. (Vinton.) 2s. 6d.
Manual of Agricultural Chemistry. By H. Ingle. (Scott, Greenwood.) 7s. 6d. net.
Maize: Its History, Cultivation, Handling, and Uses. By J. Burtt-Davy. (Longmans.) 25s. net.
Book of the Potato. By T. W. Sanders. (Collingridge.) 2s. 6d. net.
Fertilisers and Manures. By A. D. Hall. (Murray.) 5s. net.
Artificial Manures. By G. Ville and Sir W. Crookes. (Longmans.) 10s. 6d. net.
Soil Conditions and Plant Growth. By E. J. Russell. (Longmans.) 5s. net.
Birds Useful and Birds Harmful. By O. Herman and J. A. Owen. (Manchester Univ. Press.) 6s.
The Food of some British Birds. By R. Newstead. (Board of Agriculture and Fisheries.) 4d. net.
Farm, Garden, and Birds: How to Protect Grain, Fruit, and Other Crops without Destruction of Bird Life. Royal Society for the Protection of Birds. (Witherby.) 1s.
Commercial Gardening. (Gresham Publishing Co.) 4 vols. £1 16s.
Culture of Vegetables and Flowers. By Sutton & Sons. (Simpkin, Marshall.) 5s.
New Creations in Plant Life. By W. S. Harwood. (Macmillan.) 7s. 6d. net.
Injurious and Useful Insects. By L. C. Miall. (Bell.) 3s. 6d.
Fruit Farming. By C. H. Hooper. (Lockwood Press.) 3s. 6d.
Chemistry of the Garden. By H. H. Cousins. (Macmillan.) 1s.
Fruit and Its Cultivation. By T. W. Sanders. (Collingridge.) 6s. net.
Practical Fruit Culture. By J. Cheal. (Bell.) 2s. 6d.
Vegetables and their Cultivation. By T. W. Sanders, (Collingridge.) 5s. net.
A Manual of Injurious Insects. By W. E. Collinge. (Midland Educational Co.) 12s. 6d. net.
Manual of Injurious Insects and Methods of Prevention. By E. A. Ormerod. (Simpkin, Marshall.) 5s.

Poultry

Poultry-keeping as an Industry for Farmers and Cottagers. By E. Brown. (Arnold.) 6s. net.
Poultry for Prizes and Profit. By J. Long and W. M. Elkington. (Upcott Gill.) 6s. net.
Races of Domestic Poultry. By E. Brown. (Arnold.) 6s. net.
Poultry Diseases and their Treatment. By B. F. Kaupp. (Baillière, Tindall & Cox.) 5s. net.

Live-stock

The Feeding of Crops and Stock. By A. D. Hall. (Murray.) 5s. net.
Farm Foods. By E. von Wolff. Translated by H. H. Cousins. (Gurney & Jackson.) 8s. 6d.
The Feeding of Animals. By W. H. Jordan. (Macmillan.) 6s. 6d. net.
The Book of the Goat. By H. S. Holmes Pegler. (Upcott Gill.) 6s. net.
The Goat: Its Use and Management. By J. T. Bird and T. W. Sanders. (Collingridge.) 1s. 6d.
Horses, Past and Present. By Sir W. Gilbey. (Vinton.) 2s.
The Horse: Its Origin and Development, combined with Stable Practice. By R. F. Meysey Thompson. (Arnold.) 15s. net.
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A study of the psychological technique by which dreams can be interpreted, and upon the application of which every dream may be introduced into an assignable place in the psychic activity of the waking state. The author endeavours to explain processes which give rise to the strangeness and obscurity of dreams, and to discover through them the nature of the psychic forces which operate to produce the dream.

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A book that has had a European circulation and excited discussion in almost every language. The unrelieved pessimism of Lombroso reaches its deepest depths in this volume, which seeks to identify genius with degeneration. The author gathers his instances from a very wide field, but tinges them all with his peculiar hopelessness. The chief credit of Lombroso is that, in making men answer him, he makes them think.

Psychical Research. By Sir W. F. Barrett. 246 pages. Williams & Norgate .. .. 1s. net
This work, by a recent Professor of Physics in the Royal College of Science for Ireland, treats of unconscious muscular action, thought-reading, thought-

transference, hypnotism and suggestion, telepathy, phantasms of the living and dead, dreams and crystal-visions, spiritualism, survival after death, etc. A fascinating little book. Bibliography.

Human Personality, and its Survival of Bodily Death. By Frederic W. H. Myers. Abridged by his son. 470 pages. Longmans .. .. 10s. 6d. net
An admirable abridgement of one of the most remarkable books of recent times, which the author describes modestly as an "imperfect textbook to a branch of research whose novelty and strangeness call urgently for provisional systematisation." The evidences Myers accumulated were to him "signals glimmering out of night to tell man of his inmost nature and his endless fate."

Personality. By A. W. Momerie. 134 pages. Blackwood .. .. 3s.
This brief essay has had more influence in the history of thought than many great volumes. It is the brilliant reassertion of free will as against the materialists and determinists.

A Study of British Genius. By Havelock Ellis. 314 pages. Hurst & Blackett.. .. .. 7s. 6d.
The greater part of the book is devoted to the arrangement and collection of all available facts, the Dictionary of National Biography being the source of most of the materials. Concludes that the characteristics of men of genius are probably independent, to a large extent, of the particular field in which their ability is shown. Youngest and eldest children are generally the most gifted.

The Psychology of the Emotions. By T. Ribot. 455 pages. Walter Scott .. .. 6s.
Professor Ribot here continues the psychology studies which gained such a sensational prominence through the theories of William James and Lange. The book consists of two parts. The first studies the more general manifestions of feeling—pleasure and pain; the second deals with special emotions —fear, anger, sympathy, social and moral feeling, the æsthetic sentiment, and abnormal and morbid characters.

Apparitions and Thought-Transference. By F. Podmore. 401 pages. Illus. Walter Scott. 3s. 6d.
The author of this work is one of the enthusiasts who have founded the Society for Psychical Research, and here he aims at presenting, in a brief compass, a selection of the evidence upon which the hypothesis of thought-transference or telepathy is based. It does not lose but rather gains in weight by being an abridged edition of a larger book. It ranks with Mr. F. W. H. Myers's "Human Personality" as a book that must be read by all who would examine the evidence for a world of ghosts.

Animal Magnetism. By Alfred Binet and Charles Fère. 378 pages. Kegan Paul .. .. 5s.
An account of special researches into hypnotism and suggestion, undertaken chiefly at the famous French institution the Salpêtrière. Gives history of hypnotism from Mesmer, and describes ways of producing hypnosis and the symptoms of the hypnotic states. Has a chapter on hallucinations, and one on hypnotism and responsibility.

Alterations of Personality. By Alfred Binet. 365 pages. Chapman & Hall .. .. .. 6s.
Monsieur Binet brings together a storehouse of recorded facts on such fascinating themes as successive and co-existent personalities in the same life, and changes of personality by experiments in suggestion.

Hallucinations and Illusions. By E. Parish. 390 pages. Walter Scott .. .. .. 3s. 6d.
The International Congress of Sociology, meeting at Paris in 1899, originated an international census of waking hallucinations in the sane. The author of this book was engaged on that inquiry, with the result that he collected the information which is included in this volume, as a supplement to the results of the inquiry. An abstruse subject is treated with most industrious illustration.

Hypnotism and Suggestion. By Bernard Hollander. 300 pages. Pitman .. .. .. 6s. net
The result of thirty years' practical experience of hypnotism in daily life, education, and medical practice. Dr. Hollander considers two aspects of hypnotism—first, the value of the study of its psychic phenomena; and, second, its value as a therapeutic agent for the amelioration and cure of nervous and mental disorders. There are large numbers of recorded cases in recent experiments.

Illusions: A Psychological Study. By James Sully. 390 pages. Kegan Paul .. .. .. 5s.
A survey of the field of error, embracing not only the illusions of sense that may be included under a study of physiological optics, but also hallucinations, dreams, illusory introspection, and the deceits of memory and belief. A useful bibliography is included as an appendix.

Hypnotism. By Albert Moll. Walter Scott. 6s.
A thorough survey of "all that is most important in the whole province of hypnotism." Deals with the various theories of hypnotism, and describes original experiments. Medical and legal aspects of hypnotism are also considered, and there is a long chapter on occultism, a bibliography, and an excellent index of subjects and names.

Sanity and Insanity. By C. Mercier. 395 pages. Illustrated. Walter Scott .. .. .. 3s. 6d.
In this book the lecturer on insanity at the Westminster Hospital Medical School reviews almost the whole of his painful subject. It is an individual study, as many of the doctrines advanced admittedly are not accepted by the profession at large. The subject is made interesting both by completeness of knowledge and candour of expression.

Unsoundness of Mind. By Sir Thomas S. Clouston. 360 pages. Methuen .. .. .. 7s. 6d. net
Written rather for the general public than for experts. The book traces the mental history of a large number of families in the Orkneys, the writer contending that there should be more public knowledge of the conditions of mental aberration. An interesting and valuable work.

The Psychology of Insanity. By B. Hart. 176 pages. Cambridge University Press .. .. 1s. net
A work interesting not only to the medical man but also to the general reader, inasmuch as mental aberrations are in some degree present even in the sanest. The book is much influenced by the new and revolutionary ideas of Professor Freud of Vienna, who regards insanity not principally as a disease of the brain, but rather as arising from painful and disordered ideas. Bibliography.

How We Think. By John Dewey. Harrap 3s. 6d.
An elementary and practical study of psychology by the Professor of Philosophy in Columbia University. Has interesting side-tracks into logic, philology, and ethics.

Animal Behaviour. By C. Lloyd Morgan. 344 pages. Illustrated. Arnold .. .. .. 7s. 6d. net
The behaviour of animals implying intelligence, emotions, and unconscious instinct. Begins with the behaviour of cells, the behaviour of plants, and traces the development of consciousness in the individual intelligence and social actions.

The Evolution of Animal Intelligence. By S. J. Holmes. Bell .. .. 12s. net
This is an attempt, by a zoological expert of the University of Wisconsin, to trace animal intelligence back to its faintest beginnings in crustaceans and molluscs. Instinct arises earlier, according to the author. Intelligence is then traced onward, up to the mammals, which the author seems to think stop short of reasoning except in the case of men. An interesting and impartial book.

Researches on Irritability of Plants. By J. C. Bose. Longmans .. .. 7s. 6d. net
The author has found an automatic method of recording the response made by plants to excitation, without having recourse to the tedious method of photography. An account of a vast number of experiments is given, with a precision, detail, and wealth of illustration that prove the care and thoughtfulness of the experimenter and author.

Behaviour of the Lower Organisms. By H. S. Jennings. Macmillan .. .. 12s. 6d. net
The lower organisms experimented on as described in this book are chiefly one-celled organisms—amœba, bacteria, infusoria. The author tells of many attempts to stimulate them and induce reactions. He then passes on from behaviour that is perhaps mechanical to that which is psychic, springing, for example, from what seems an impulse of fear. The whole book is a fine example of modern experimental research.

Response in the Living and Non-Living. By J. C. Bose. Longmans .. .. .. 10s. 6d.
First the author explains "response" through the action of muscle; then studies electric and other forms of response, in plants, under varied conditions, such as temperature, prisms, and anæsthetics. Response is next studied in metals. Inorganic response is then carefully studied. A work of great experimental zeal and ability. The author is a professor in the Presidency College, Calcutta.

Philosophy

Aristotle. By Sir A. Grant. Blackwood.. 1s. net
An excellent sketch for the general reader of the life and work of the great Greek systematiser of knowledge, written by one who made his subject a life-study, and is admitted to be an authority on it, as well as an attractive popular expositor.

Aristotle and the Earlier Peripatetics. By E. Zeller. 1051 pages. Two vols. Longmans .. 24s.
A translation by B. F. C. Costelloe and J. H. Muirhead from Zeller's "Philosophy of the Greeks," and the most readily available general survey of Aristotle's works, with extended reproductions of the writings, and separate works on separate books.

Aristotle's Works. Translations by various writers.
Psychology. By W. A. Hammond. Allen. 10s. 6d
De Sensu and De Memoria. By G. R. T. Ross. Cambridge University Press .. .. 9s.
Nicomachean Ethics. By R. W. Browne. Bell. 5s.
The Organon. By O. F. Owen. Two vols. Bell. 5s.
Politics. By Benjamin Jowett. Clarendon Press. 3s. 6d.
Rhetoric. By J. E. C. Welldon. Macmillan. 7s. 6d.
Education. By John Burnet. Cambridge University Press .. .. 2s. 6d.

Plato and Platonism. By Walter Pater. 286 pages. Macmillan .. .. 7s. 6d. net
A scholarly presentation of Plato's doctrines, and sketch of his personality, for students of philosophy, by a writer who is as great a master of English as of Greek. A notable book, alike because of its subject and on its own account.

Plato. Translations by Benjamin Jowett. Clarendon Press
The best translations of Plato are by Jowett— the "Four Socratic Dialogues," 285 pages, costing 3s. 6d. net; and "The Republic," 610 pages, 12s. 6d., or in two volumes, 7s. net.

Critique of Pure Reason. By Immanuel Kant. English translation by J. M. D. Meiklejohn. 517 pages. Bell .. .. 3s. 6d.
This work contains in all essentials the philosophical teaching of Kant, usually known as "transcendentalism." The first part contains the analysis of knowledge, or the theory of experience, which Kant based upon the principle that space and time are qualities or conditions of our sensuous apprehensions, and that a statement in which conditions of time and space are introduced can never be held to be a truth about things in themselves.

The Philosophy of Kant. By Robert Adamson. 269 pages. Douglas .. .. 6s.
The writer is an enthusiastic disciple of Kant, who regards the Kantian philosophy as offering the only sound and fruitful basis for speculation, and, unlike his master, has the power of clear expression and popular exposition.

Kant's Critical Philosophy for English Readers. By J. P. Mahaffy and J. H. Bernard. Two vols. 658 pages. Macmillan .. .. .. 13s. 6d.
A translation of Kant—the "Kritik" and the "Prolegomena"—for advanced students who wish to really master the master. It contains an abundance of notes and much helpful information.

The Principles of Ethics. By Herbert Spencer. Two vols. Williams & Norgate .. .. 27s. 6d.
This work the author regarded as the crown of his system of thought. It aims at reducing morality to a science, and conduct is examined as it hinders or develops the welfare of the individual and the race. Spencer tries to show that self-sacrifice is a transitional and passing phase of morality, and that, as the evolution of society goes on, private welfare and public welfare tend largely to coincide.

Epitome of the Synthetic Philosophy of Herbert Spencer. By F. H. Collins. 692 pages. Williams & Norgate .. .. 5s. net
An excellent summary of Spencer's far-ranging theories and ideas, which was prepared under the authority of the great thinker. The work sets out from the idea of an unknowable First Cause behind everything, and deals with the field of actual knowable things—life, mind, sociology, and morality. It follows closely the arrangement of Spencer's works, and condenses his statements and arguments.

First Principles. By Herbert Spencer. 706 pages. Williams & Norgate. .. .. .. 2s. net
The chief work of the greatest of modern thinkers, and written in a somewhat easier style than the more specialised volumes of his philosophic system. It contains an explanation of all the fundamental ideas running through his other works, and is the best book for the student of Spencer to start on.

On Liberty. By John Stuart Mill. Longmans. 74 pages 1s. 4d
A philosophical examination of the rights of the individual in the State, and the degree of restriction that is just and necessary. The most carefully written and patiently thought out of all Mill's writings. The trend of events since Mill's day has been all in the direction of sinking individual claims in the wider claims of the State, a tendency which causes individualists to place a higher value on Mill's arguments, as being more and more needed.

The Ethics of John Stuart Mill. Edited by Charles Douglas. 359 pages. Blackwood .. 6s. net
The most usable edition of Mill's ethical writings, accompanied by such comments and introductions as will guide and stimulate the student. The editor holds that there is an inherent difficulty in reconciling individualism with an altruistic ethical theory, and that Mill's writings bring out the points.

Principles of Political Economy. By John Stuart Mill. 611 pages. Longmans .. .. 3s. 6d.
The book that is most generally accepted as the standard work on its subject. It builds on the foundations laid by Adam Smith, and in the main establishes what are now regarded as traditional beliefs, though its teachings are modified at various points by later students.

A System of Logic. By John Stuart Mill. 638 pages. Longmans .. .. 3s. 6d.
One of the most useful and permanent of the writings of Mill. For students rather than the general reader. Described by its author as "a connected view of the principles of evidence and of scientific investigation."

Essay on Human Understanding. By John Locke. Routledge .. .. 3s. 6d.
The masterpiece of John Locke, the English philosopher, who, before Herbert Spencer, had a greater influence on Continental thought than any other English writer. It denies the doctrine of innate ideas, and argues that knowledge must be a gradual growth based on experience. All ideas may be referred back to the senses, or to reflection by the mind on the materials gathered by the senses.

On Civil Government. By John Locke. 245 pages. Routledge .. .. 1s.
This edition includes Sir Robert Filmer's "Patriarchia," the book which led Locke to discuss the true bases of civil government, and define the political philosophy of the Whig Party.

Locke. By A. C. Fraser. Blackwood .. 1s. net
A good all-round study of a great English thinker, who has exercised an influence on European thought second to that of Aristotle. Locke wrote a plain, easy style, and his biographer is also very readable. He deals with the life, thought, and influence of Locke, marking his limitations as well as explaining his ideas and estimating his large, original contributions to the intellectual riches of mankind.

Francis Bacon: His Life and Philosophy. By John Nichol. Two vols. Blackwood .. 2s. net
A scholarly and popular exposition of Bacon's philosophy and work, with an extended sketch of his life, suitable both for the general reader and for the student who wishes to place Bacon properly in the sequence of thinkers.

Man and the Bible. By J. Allanson Picton. Williams & Norgate .. .. .. 6s. net
An exceedingly broad-minded review of the place of the Bible in human history. It attempts to separate between the natural power of the book over man's minds through its presentation of great self-evident truths, and the fetishism which accepts the Bible superstitiously.

Elements of Natural Philosophy. By Lord Kelvin and P. G. Tait. Cambridge University Press. 9s.
An investigation of laws in the material world, with the deduction of results. Gives a complete account of the subject in language adapted to the non-mathematical reader, and furnishes a connected outline of the intellectual processes by which the greater part of the knowledge has been extended into regions as yet unexplored by experiment.

A History of Intellectual Development in Europe. By John W. Draper. Two vols. Bell. .. 10s.
A bright survey by an American author, whose temperament led him towards sharp controversy.

History of European Morals. By W. E. H. Lecky. Popular editions. Longmans .. 2s. 6d. net
The period covered by Professor Lecky's survey is from Augustus to Charlemagne only. Everything Lecky wrote stimulates thought.

A History of Freedom of Thought. By J. B. Bury. 256 pages. Williams & Norgate. .. 1s. net
The story of the emancipation of reason, told, from the days of Greece till now, with remarkable lucidity and power, by the distinguished Regius Professor of Modern History, Cambridge.

History of the Rise and Influence of Rationalism. By W. E. H. Lecky. Longmans. .. 2s. 6d. net
A masterly sketch of the change of the world from a subservient acceptance of religious tradition towards freedom of thought and belief. "A remarkable contribution to the history of the human mind and human society."

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Noncomformity, its Origin and Progress. By W. B. Selbie. 253 pages. Williams & Norgate. 1s. net
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Three volumes of the Home University Library (Williams & Norgate), 1s. net each volume, succinctly tracing the growth of government and the evolution of national and social consciousness.

The Map of Life. By William Edward Hartpole Lecky. 353 pages. Longmans .. 2s. 6d. net
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The Childhood of Religions. By Edward Clodd. Kegan Paul.. .. .. 1s. 6d.
The early growth of religion traced, from Nature worship onward, and its development into a variety of faiths of different quality. A simple introduction to the study of comparative religion. Written in a fascinating style.

The Elements of Ethics. By J. H. Muirhead. 310 pages. John Murray .. .. 3s.
One of the clearest and most interesting of the books on ethics for the use of beginners, with the advantage of being quite up to date, and admirably co-ordinated with allied studies.

Ethics. By G. E. Moore. Williams & Norgate. 1s. net
As simple a discussion of the fundamental question of conduct as is possible in a brief and popular work. The main subjects under notice are utilitarianism, moral judgments, tests of right and wrong, free will, and intrinsic value. Mr. Moore has the power of giving an abstruse subject more tangibility than philosophers can usually suggest.

The Greek View of Life. By G. Lowes Dickinson. 248 pages. Methuen .. .. .. 2s. 6d. net
This work, by a Cambridge scholar, has gone through eight editions. It treats with great insight of the Greek views of religion, of the State, of the individual, and of art, with appropriate quotations from classic writers.

The Science and Philosophy of the Organism. By Hans Driesch. Two vols. Black .. 21s.
An abstruse and somewhat involved statement of a very interesting theory of life. The author regards the life-force as a self-governing thing that evolves according to its own laws and to the circumstances in which it is placed. Dr. Driesch goes back to Aristotle for his ideas of life, but interprets these ideas in the full light of modern research.

Man's Origin, Destiny, and Duty. By Hugh MacColl. Williams & Norgate .. 4s. 6d. net
An attempt to prove that the soul and the body are different entities; and the soul will survive the body by successive transformations, and will gradually develop upwards; that the psychic universe contains numberless ascending orders of intelligent beings above the human, though they are imperceptible to man's senses; and that the whole creation is maintained and directed by one infinitely powerful and intelligent being. The execution of the work is much less comprehensive than its aim.

The Psychology of Religion. By E. D. Starbuck. 423 pages. Diagrams. Walter Scott .. 6s
In a preface to this book, Professor William James the most eminent of American psychologists, describes it as bringing compromise and conciliation into the long-standing feud between science and religion, and he recommends it as affording matter for edification and improvement to Christians and scientists alike.

Conventional Lies of Our Civilisation. By Max Nordau. 346 pages. Heinemann .. .. 6s.
Tracing the causes of his dismal pessimism, the author finds them in having to live in the midst of institutions which he regards as false. Religion, monarchy, aristocracy, politics, economics, and marriage are alike treated as insincerities that afford evidence of race degeneracy. The reader is taken, groaning, through the very depths of despair.

The Duties of Man. By Joseph Mazzini. Cheap editions.
Mazzini in this book enforces the central idea of his political creed—that men go astray in making their rights the chief concern of their public lives. Having obtained liberty, they should initiate a constructive policy with duty as the watchword, and should not make gain their aim, but the building up of a worthier public and personal character.

The Social Contract. By Jean Jacques Rousseau. Allen & Unwin .. .. 1s. net and 2s. 6d.
The most accessible English edition of an epoch-making book, with a useful introduction and explanatory notes by the translator, H. J. Tozer. Rousseau argues in the book that government depends upon a social contract whereby the individual surrenders some of his individuality for assured protection by the State. Hobbes had advanced a similar argument, while Rousseau emphasises the State's obligations to the individual.

The Prince. By Machiavelli. Cheap editions.
A work of considerable political and historical interest, which has given to Machiavelli so sinister a reputation. The reader who remembers the period and country of the author will find that evil reputation undeserved.

Descartes: The Method, Meditations, and Selections from His Principles. By Professor J. Veitch. 473 pages. Blackwood .. .. .. 6s. 6d.
The best introduction to the thought of Descartes. Informative, explanatory, critical.

Henri Bergson. By H. Wildon Carr. 92 pages. Jack .. .. 6d.
This introductory sketch aims only at giving a general survey of the scope and method of the great French philosopher of today.

Berkeley. By A. C. Fraser. 242 pages. Portrait. Blackwood .. .. 1s. net
An admirable summary account, in Blackwood's Philosophical Classics, by Professor Fraser, of Berkeley, the man and his thought. The effects of the philosopher's writings are traced through later thinkers with enthusiastic appreciation.

The Great Illusion. By Norman Angell. 331 pages. Heinemann .. .. 2s. 6d. net
One of the most widely read books of the present day. A study of war between civilised nations from the economic aspect, showing that it must be uneconomic in its effects, and damage the victors more than it can advantage them.

Leviathan. By Thomas Hobbes. Routledge. 1s.
The book which underlies all modern discussions of the principles of public government. The State is depicted as Leviathan, and all-powerful. But Hobbes goes on to concentrate the powers of the State in the Sovereign who, as the representative of all, is endowed with supreme powers over public policy, civil and religious. The book led thinkers—notably Locke—to lay down the logical bases of civil liberty.

Fichte. By Robert Adamson. 222 pages. Blackwood .. .. 1s. net
A very able summary of the salient features of Fichte's philosophy, with an account of the philosopher. A difficult subject well handled.

Dictionary of Philosophy and Psychology. By J. M. Baldwin. 3 vols. Macmillan. 110s. net
The most complete general survey of the literature of man's study of the mind and of the subjects discussed in that literature. International in its scope and expression, and fully illustrated. A work of very high value, indispensable in any library of philosophy.

The Springs of Conduct. By C. Lloyd Morgan. 317 pages. Arnold .. .. 7s. 6d.
An essay in the evolution of ethics, by the well-known writer on animal intelligence. Extremely fresh and vigorous. All works on ethics are curiously remote from actuality, and this one is no exception to the rule, but it is far from being as bad as most.

The Nature of Man. By E. Metchnikoff. 309 pages. Illustrated. Heinemann .. .. 6s. net
This English translation of the "studies in optimistic philosophy," by the great Russian pathologist, is of great interest. The author describes first an extraordinary collection of "disharmonies in the nature of man"; then deals with religious and philosophical systems designed to diminish these; and, thirdly, with triumphant science.

Introduction to Science. By J. Arthur Thomson. 251 pages. Williams & Norgate .. 1s. net
Dr. Thomson, Professor of Natural History in Aberdeen, a profound and wide thinker, here deals with the scientific mood, the aim of science, scientific method, classification of the sciences, science and philosophy, science and art, science and religion, and the utility of science. A suggestive book.

The Grammar of Science. By Karl Pearson. Third edition. 394 pages. Black .. .. .. 6s. net
A revised and enlarged edition of a remarkable survey of modern knowledge. Intended as a criticism of the fundamental ideas of science, it has also a constructive aim. All the principal fields of thought and research are studied.

The Interpretation of Nature. By C. Lloyd Morgan. 164 pages. Arrowsmith .. .. .. 2s. net
Dr. Lloyd Morgan sets out to show that a belief in a divine purpose in the universe is not inconsistent with a whole-hearted acceptance of scientific ideas and methods.

Creative Evolution. By Henri Bergson. 425 pages. Macmillan .. .. 10s. net
The book that has been more discussed in the philosophical world than any other during the last few years. The translation is by Dr. Arthur Mitchell, of Harvard University, and Professor Bergson himself has revised the whole work carefully. His summary of his aim is that he first tries on evolutionary progress the two ready-made garments of mechanism and finality, and shows that neither fits. Next he reconstructs the main lines of evolution along which life has travelled by the side of that which has led to the human intellect. The intellect is thus brought back to its generating cause. Last, the writer tries to show how our understanding, by submitting to a certain discipline, can prepare a transcendental philosophy. This is the book on which the whole controversy respecting Bergson's philosophy is based.

Facts and Comments. By Herbert Spencer. 205 pages. Williams & Norgate .. .. .. 6s.
The last fruit from an old tree. Touches on many social subjects of present interest, and gives the great thinker's last thoughts on the ultimate questions of life.

Social Evolution

Origin of Civilisation. By Lord Avebury. 482 pages. Illustrated. Longmans .. 7s. 6d. net
Lord Avebury describes the social and mental conditions of savages, their art, marriage, family relations, religion, language, polity, and laws. Though the savages of today do not necessarily represent very accurately the condition of primitive man, the book is of great value to the student of social evolution.

The Dawn of Civilisation. By Sir G. Maspero. 800 pages. Illustrated. English translation by M. L. McClure. S.P.C.K. .. .. .. 21s. net
This great work, by a master of Egyptian science and of Oriental history and archæology, describes the ancient civilisations of Egypt and Chaldæa.

History of Civilisation. By Charles Seignobos. 3 vols. Fisher Unwin .. 2s. 6d. net per vol.
A wide survey of the history of ancient, mediæval, and contemporary civilisation — one volume devoted to each period. Popularly written, with valuable references for supplementary reading.

The Dawn of History. By J. L. Myres. 256 pages. Williams & Norgate .. .. .. 1s. net
The author of this work is Professor of Ancient History in Oxford University. He here traces in many parts of the world the story of those crises or generally abrupt changes through which nations emerge out of the unhistoric sameness of primitive life into the striving process of the "historic age," frequently through the efforts of some "great man."

History of Civilisation in England. By T. H. Buckle. Three vols. .. .. .. Cheap editions
A brilliant attempt to ascertain the laws and principles of human progress, and to trace their operation in English history. A stimulating work, but inaccurate in detail, and not generally accepted nowadays. The author contends that civilisation is largely affected by natural conditions.

Principles of Western Civilisation. By Benjamin Kidd. 518 pages. Macmillan .. .. 5s. net
Presents European civilisation as a developing system of life, with more organic unity than any of the nations or states included in it, and with a special meaning and purpose of its own. The purpose is to build up a better state of things in the immediate future; a projected efficiency that calls out the noblest energies of the race, and gives meaning to the self-sacrificing acts of the individual.

Extinct Civilisations of the West. By R. E. Anderson. 200 pages. Illustrated. Hodder & Stoughton 1s. net
A brief account of the traces of Norse colonies in Greenland and other parts of North America centuries before Columbus; of Welsh and Irish Celts who preceded even the Norsemen; of the Aztecs, their traditions, their hieroglyphics, their human sacrifices, religious services, their remarkable scientific knowledge, etc.; and of American archæology in general.

Extinct Civilisations of the East. By R. E. Anderson. 229 pp. Illus. Maps. Hodder & Stoughton 1s. net
A work on the origin and races of mankind: Chaldea and Babylonia; ancient Egypt; the Hittites, Phœnicians, and Hebrews; the Arab; and Iran, or ancient Persia. Interesting historical and ethnological chapters, valuable to the general reader, and to the student of Old Testament history.

The History of Mankind. By Friedrich Ratzel. Translated by A. J. Butler, with an introduction by E. B. Tylor. Three vols Illustrated. Macmillan .. .. 36s. net
A guidebook to the study of man and civilisation. To those beginning anthropological work it gives indispensable sketches of the races of mankind, especially of the barbaric peoples who display culture in its earlier stages. The illustrations number nearly twelve hundred. Popular in treatment and scientific in spirit.

The Childhood of Man. By Leo Frobenius. English translation by A. H. Keane. 504 pages. Illustrated. Seeley .. .. 16s. net
An admirable description of many aspects of primitive races, including personal adornment, tattooing, tests of manhood, origin of labour, dress language, sign and gesture language, etc.

The Child: A Study in the Evolution of Man. By Dr. Alexander Francis Chamberlain. 405 pages. Illustrated. Walter Scott .. .. .. 6s.
An extremely interesting book, tracing the most important phenomena of human beginnings in the individual and the race. The child is treated as a revealer of the past, and as indicating in its growth the progress of mankind. In making his investigations the author has covered a wide range of literature; indeed, the bibliography of books used fills thirty pages.

Ancient Types of Man. By Arthur Keith. 151 pages. Illustrated. Harpers .. .. 2s. 6d.
A clear and readable account of the types of mankind whose remains have been discovered at various depths in the earth. Professor Keith is an authority on the subject, and he has an original point of view on some problems of human origin.

Man Before Metals. By N. Joly. 365 pages. Illustrated. Kegan Paul .. .. 5s.
This brightly written book collects the proofs of the

great age of the human race, and in a second part treats of the customs, the industry, the moral and religious ideas of man as he existed before the use of metals was known.

Man and His Handiwork. By Rev. J. G. Wood. Illustrated. S.P.C.K. .. .. .. 5s. net
An interesting endeavour to trace out the history of the human race from the handiwork of man throughout the ages; the meaning of the weapons and utensils discovered by geologists, and their light on the life of the men who used them. There are about 500 pictures.

The Primitive Family in Its Origin and Development. By C. N. Starcke. 315 pages. Kegan Paul 5s.
Aims at ascertaining the nature of the primitive family, and points out the ideas on which it is based and the germ of moral growth it contains. Gives the theories of McLennan and Maine, and surveys the family arrangements of savages in all parts of the world.

Primitive Man. By E. Clodd. Illustrated. Hodder and Stoughton .. .. 1s. net
A concise popular introduction to the study of man in the Stone and Metal Ages, containing a bibliography. The primitive ideas of barbaric nations are quoted to illustrate the probable meanings of prehistoric remains, and the positions in which they are sometimes found.

Ancient Hunters and Their Modern Representatives. By W. J. Sollas. 416 pages. Illustrated. Macmillan .. .. 12s.
The clearest and fullest work on the study of the arts and conditions of the primitive inhabitants of Europe. Combines the most recent researches of French anthropologists and German geologists with the views of British students of the problems of prehistory. Shows that probably the ancestors of Tasmanian and African Bushmen dwelt in Europe in the warm intervals between the Great Ice Ages.

Anthropology. By Sir Edward Tylor. 463 pages. Illustrated. Macmillan .. .. .. 7s. 6d.
An admirable introduction to the study of primitive and savage man. A large and varied field of facts is surveyed in a clear, orderly manner by a leading authority, and the principal ideas are presented in an easy style, suitable for the general reader. A standard work.

Anthropology. By R. R. Marett. 256 pages. Williams & Norgate .. .. .. 1s. net
Mr. Marett is Reader in Social Anthropology in the University of Oxford, and an acknowledged authority on the customs and beliefs of primitive races. Anthropology, he says, studies man as he occurs at all times, and in all known parts of the world. It deals with such questions as race, language, environment, social organisation, law, religion, morality, especially in so far as individual traits reveal the universal.

Man and His Ancestor. By Charles Morris. Macmillan .. .. 5s. 6d. net
An effort to present the evolution of man in a popular manner by dwelling on facts discovered since the time of Darwin.

The Mind of Primitive Man. By Franz Boas. Macmillan .. .. 6s. 6d.
The chapters of this book are reprints of lectures delivered at the Lowell Institute, Boston. First the author tries to clear away racial prejudice, which he holds is insufficiently supported. He then discusses the influence of environment and of heredity, compares the mental traits of primitive and civilised man, and comes to the conclusion that culture is a phenomenon that depends on historical causes regardless of race. A thoughtful book, provocative of keen controversy.

Ethnology. By A. H. Keane. 425 pages. Illustrated. Cambridge University Press .. 10s. 6d.
Deals with the fundamental problems of the division of mankind into races, and then describes the primary racial groups. Written in a clear and interesting style by a master of anthropology.

Man: Past and Present. By A. H. Keane. Cambridge University Press .. .. .. 12s.
An exceedingly able survey of the chief racial divisions of mankind, and an examination of the changes since prehistoric times that have led to fresh ethnical groupings. The book is a complement of the author's work "Ethnology."

The Measurement of Social Phenomena. By Dr. A. L. Bowley. P. S. King .. .. 3s. 6d. net
This book deals with "the general problem of sociological statistics which defines or deliminates and enumerates classes, specifies attributes or characteristics of the members of those classes, measures these attributes and describes their variation, and discovers relations and casual connections." That is the publisher's own summary, but the book is not so dull as that summary suggests. It is a study of the measurement of progress by statistics.

Primitive Folk. By Elie Reclus. 336 pages. Illustrated. Walter Scott .. .. .. 3s. 6d.
Monsieur Reclus attempts to draw the ethnic individualities of a number of the more primitive races—races that are as children, with the intelligence of a child. He chooses his subjects from all climates between the extremest Polar regions and the equator. The book as a record of life is interesting, and still more as giving many forms of development of the mind of primitive man.

The Races of Man. By J. Deniker. 611 pages. Illustrated. Walter Scott .. .. .. 6s.
Gives the essential facts of the twin sciences of anthropology and ethnography. Designed for all those who desire to obtain a general notion of these sciences rapidly. The book brings into one volume a mass of valuable information gleaned from a great number of notes and memoirs in all languages.

The Human Species. By A. de Quatrefages. 498 pages. Kegan Paul .. .. 5s.
Discusses the unity of the races of man, the origin of mankind, the birthplace of primitive man, and the peopling of the earth. One part is given up to a description of fossil human races, which is now incomplete, owing to later discoveries. The last parts depict the physical and mental characteristics of existing races.

The World's Peoples. By A. H. Keane. 434 pages. Illustrated. Hutchinson .. .. 6s. net
A popular account of the bodily and mental characters, beliefs, traditions, and political and social institutions of the races of the world. Well illustrated by many photographs.

Prehistoric Peoples. By the Marquis de Nahaillac. 412 pages. Illustrated. Putnam .. 12s. 6d.
Claims to be an epitome of the manners and monuments of prehistoric peoples. Discusses the time and duration of the Stone Age; the life and habits of the people; their weapons and industries; the origin of fire, clothing, and ornaments; the beginnings of art and social organisations; the setting up of camps and fortifications; and the dawn of surgery.

Prehistoric Man. By W. L. H. Duckworth. 161 pages. Illus. Cambridge University Press. 1s. net
This book deals with the earliest phases in the history of mankind. It begins with the precursors of Palæolithic man, intermediate between mankind and the more highly developed apes, and follows on through the association of primitive man with animal remains, to the evolution of the higher human types.

Prehistoric Times. By Lord Avebury. 616 pages. Illustrated. Williams & Norgate .. 10s. 6d. net
This history of ancient man is derived from prehistoric remains found in various parts of the world, and from a study of the manners and customs of modern savages. The book is well illustrated with pictures of implements, works of art, and so on, from the prehistoric ages.

Prehistoric Europe. By James Geikie. 592 pages. Illustrated. Stanford .. .. .. 25s.
An outline of the chief physical changes on the Continent of Europe since the beginning of the Pleistocene period. The successive changes of climatical and geographical conditions are examined systematically.

The Stone Ages. By the Rev. Frederick Smith. 377 pages. Illustrated. Blackie .. .. 16s. net
An account of the flint implements found in North Britain and Ireland, with deductions of great interest and importance which the author has been able to draw concerning the nature of ancient man. There is considerable evidence of his having possessed heroic qualities and great ingenuity, and possibly also domestic qualities. An extremely interesting book.

Rough Stone Monuments and Their Builders. By T. Eric Peet. Illustrated. Harper. 2s. 6d. net
Written to enable those interested in Stonehenge and other great primitive monuments of Britain to learn something of similar buildings existing in different parts of the world. A summary of the latest researches on the subject, by one of the leading authorities of the younger generation.

The Ancient Stone Implements, Weapons, and Ornaments of Great Britain. By Sir John Evans. 747 pages. Illustrated. Longmans .. 10s. 6d. net
The standard work on the prehistoric instruments of the early inhabitants of Great Britain. A cautious and painstaking man of science, Sir John Evans has tried to reduce to order the various small objects of human manufacture found in the river gravels, caves, and haunts of the primitive Briton.

The Childhood of the World. By Edward Clodd. Macmillan .. .. 4s. 6d. net
An account of the thoughts and surroundings of the earliest men, when the greatest of all inventions—such as the uses of fire, the development of language, and the beginnings of writing—were coming into use. Written with great charm.

Remains of the Prehistoric Age in England. By Sir B. C. A. Windle. 312 pages. Illustrated. Methuen.. .. .. 7s 6d. net
An interesting and well-illustrated book by the President of Cork University College. It deals fully with stone, metal, and bone implements, burial-places, earthworks, pit-dwellings, and with the physical remains of prehistoric man.

Life in Early Britain. By Sir B. C. A. Windle. 244 pages. Nutt .. .. 3s. 6d.
An account of the early inhabitants of this island and the memorials which they have left behind them. Deals with Palæolithic and Neolithic man; the Bronze period; the Roman occupation of Britain; the Saxon occupation; tribal and village communities, etc.

The Making of Religion. By Andrew Lang. 316 pages. Longmans .. .. 5s. net
Deals with the supposed evolution of religious ideas which finds the origin of belief in a Supreme Being in the belief in ghosts. After considering the subject from many points of view, and examining primitive beliefs and various evolutionary theories, the author refuses to concur in this opinion as to the origin of religion, and summarises the primitive beliefs in support of his contention.

The Golden Bough. By Sir J. G. Frazer. Illustrated. Macmillan. Twelve vols.

Part 1.	Two vols.	20s. net.
Part 2.	One vol.	10s. net.
Part 3.	One vol.	10s. net.
Part 4.	Two vols.	20s. net.
Part 5.	Two vols.	20s. net.
Part 6.	One vol.	10s. net.
Part 7.	Two vols.	20s. net.

Vol. XII. General Index and Bibliography. 20s. net.

The most famous of all works on comparative religion, in any language, but, in the opinion of most students, somewhat too hypothetical. The book is, however, so charming that the reader does not very much care how far it is true; and no one will ever sift truth from error in this difficult subject. Facts from all times and places, the ancient and modern world, savages and civilised peoples, are here brought together to illustrate that inscrutable mystery of religion—the sacrifice. And they are delightful facts, too: the popular festivals of peasants in spring, midsummer, and harvest; the religion of woodmen and husbandmen and their cult of trees, and especially the "golden bough," and all kinds of sad, sweet, old pagan stories. The book has now developed into seven parts, published separately. (1) "The Magic Art and Evolution of Kings." (2) "Taboo, and the Perils of the Soul." (3) "The Dying God." (4) "Adonis, Attis, Osiris." (5) "The Spirits of the Corn and of the Wild." (6) "The Scapegoat." (7) "Balder the Beautiful."

Totemism and Exogamy. By Sir J. G. Frazer. Four vols. Macmillan .. .. 50s. net
This pioneer book on the obscure subject of totemism was prepared by Sir James Frazer for the "Encyclopædia Britannica," but only a part of it was included in that work. The materials accumulated upon the author so that he had to publish them in a separate treatise. The work deals with the religious, sexual, and social aspects of totemism.

The Mediterranean Race. By G. Sergi. 320 pages. Illustrated. Walter Scott .. .. .. 6s.
Only in recent years has the origin of the nations of Southern Europe been rescued from the idea that all white peoples are of Aryan blood. The view now is being generally accepted that the Mediterranean peoples had a separate origin, and this contention, put forward here by Signor Sergi, Professor of Anthropology in the University of Rome, has not only gained acceptance, but is being attested by the excavations in Crete and elsewhere. The case for the Mediterranean stock is here presented in a convincing manner.

The Origin of the Aryans. By Isaac Taylor. 339 pages. Illustrated. Walter Scott .. 3s. 6d.
Intended to be a summary of the labours of many scholars, and a digest of the literature that has grown up concerning the prehistoric ethnology and civilisation of Europe.

The Jews. By Maurice Fishberg. 578 pages. Illustrated. Walter Scott .. .. .. 6s.
An attempt to present the results of anthropological, pathological, psychological, and demographic investigation of the Jews. Based on careful scientific research in America and Europe. The book discusses the distribution of the Jews, their physical characters, types, customs, and occupations. There is a most useful bibliography.

Society and Politics

The Principles of Sociology. By Herbert Spencer. Three vols. Williams & Norgate.. .. £2 15s.
A work that founded a new science. In it Herbert Spencer brings all the affairs of society under the law of evolution, and shows that nations and states cannot be ready-made, but are gradually formed by a process of development. In spite of the length of the work, it is uncommonly readable, as it deals with matters of vivid interest and wide appeal.

The Study of Sociology. By Herbert Spencer. 423 pages. Williams & Norgate .. .. 10s. 6d.
A summary and at points a development of the larger work, "The Principles of Sociology." But it has a special value for all students of society, in that Spencer makes it a survey of all the main problems and difficulties connected with the new social science; and many of his remarks have not lost their force.

Social Evolution. By Benjamin Kidd. 385 pages. Macmillan .. .. 7s. 6d. net
The forces working in the evolution of society, on the whole, effecting the greatest good of the greatest number in a progressive community. But the greatest number is comprised of the members of generations yet unborn or unthought of, and to whose interests the existing individuals are usually quite indifferent. So the social forces work for future more than for existing generations.

Descriptive Sociology. By Herbert Spencer, David Duncan, Richard Scheppig, and James Collier. Eight vols. Williams & Norgate .. .. £7 15s.
An enormous collection of facts relating to the various races and nations of mankind, collected by a band of scholars under Herbert Spencer's direction, and arranged and classified by the famous thinker. The work aims to supply the student of social science with facts upon which to work.

Social Statics, and the Man versus the State. By Herbert Spencer. Williams & Norgate .. 10s.
In this volume Spencer unites some of his earliest and latest ideas. Published first in 1850, "Social Statics" is more brilliantly written than Spencer's other sociological works, but, although it contains the germs of many of the ideas of the synthetic philosophy, it also contains much that Spencer outgrew. The later work, "Man and the State," asserts the rights of the individual against the increasing regulative powers of Governments.

Social Psychology. By William McDougall. 389 pages. Methuen .. .. .. 5s. net
The author here traces the working of instinct in the social life of man. Instinct, he affirms, is a mental process, and involves knowing and feeling as well as doing. The principal instincts are examined, and their social results indicated. Self-consciousness, moral judgments, volition, imitation, play, and habit are defined, and their effects traced.

Heredity and Selection in Sociology. By G. C. Hill. 600 pages. Black .. .. .. 12s. 6d.
The author gives in the first place a concise exposition of the main facts of heredity and selection, based upon recent biological researches; and this part of the work has been revised by Professor J. A. Thomson, the eminent Scottish biologist. Mr. Hill regards the principle of selection as having the greatest importance in social life, and believes that conflict is necessary in order to secure selection.

Historical Sociology. By Frank Granger. 241 pages. Methuen .. .. 3s. 6d. net
This book deals with the bases of social problems; the primary relations upon which laws and politics have actually been built up; with the individual; the will of the people; genius and destiny; marriage; religion, and regeneration. It is an elementary treatise, and contains a bibliography.

The Spirit of Laws. By M. de Secondat, Baron de Montesquieu. Two vols. 816 pages. Bell. 7s.
This translation, by T. Nugent, is the only really adequate form in which one of the most influential books of the eighteenth century is accessible to English readers. Montesquieu was an ardent admirer of the constitutionalism developed in England, and helped to spread English ideals on the Continent.

The English Constitution. By Walter Bagehot. 292 pages. Kegan Paul .. .. .. 3s. 6d.
Describes the English Constitution as it stood in the years 1865 and 1866, since which date, as the author points out, there have been many changes in spirit and in detail. This fact hardly affects the value of the book, however; it merely carries on the process beyond its limits. The author discusses the Cabinet; the Monarchy; the House of Lords; the House of Commons; changes of Ministry, and their supposed checks and balances; the pre-requisites of Cabinet government, and the peculiar form which they have assumed in England.

English Political Institutions. By J. A. R. Marriott. 347 pages. Clarendon Press .. .. 4s. 6d.
The author, a lecturer and tutor in modern history and political science at Worcester College, Oxford, holds that history should be taught from the present time backwards, and so has written an introduction to English institutions, explaining the contemporary working of the constitutional machine; the executive, legislative, local government, judiciary, and the relations between the Mother Country and Empire. An excellent book, non-political, clear and comprehensive.

Parliament. By Sir Courtenay Ilbert. 256 pages. Williams & Norgate .. .. .. 1s. net
This excellent little book, by the Clerk to the House of Commons, gives a complete condensed account of the history, constitution, and practice of the English Parliament, and includes a comparison with the constitution and procedure of government in other countries. Contains a classified and critical bibliography of considerable value.

Housing. By Percy Alden and Edward E. Hayward. 168 pages. Headley .. .. .. 1s. net
This little book, by two well-known social reformers, gives a concise account of the history of housing legislation, and an excellent brief study of the chief issues of the problem. The authors warmly support the garden-city movement. The problems of London traffic are also discussed as bearing on the housing problem; and an excellent bibliography is included.

Public Health and Housing. By John F. J. Sykes. 216 pages. P. S. King .. .. .. 5s.
This book divides itself into three parts: the ascertained effects upon health of certain conditions of habitation; construction and misconstruction of

human dwellings; and usage and misusage. A thoughtful book, the outcome of wide experience on a serious problem.

History of Trade Unionism. By Sidney and Beatrice Webb. 558 pages. Longmans .. 7s. 6d. net
In describing the growth and development of the trade union movement, the authors give the political history of the English working class for nearly two hundred years. The trade union organisation of today is described in detail. The last chapter contains a realistic sketch of actual trade union life, by a trade union secretary. Bibliography.

Co-operation at Home and Abroad: A Description and Analysis. By C. R. Fay. King. 10s. 6d. net
A comprehensive examination of the co-operative movement as it has developed in the countries of Europe that are most advanced socially. The author shows how some phases of the movement are more suitable than others to national idiosyncracies.

The Co-operative Movement in Great Britain. By Mrs. Sidney Webb. 260 pp. Allen & Unwin. 2s. 6d.
A book written in the days when the author was Miss Beatrice Potter, but many times reprinted. It describes the origin and growth of the British co-operative movement towards industrial democracy, and introductory chapters give a general view of the condition of the working classes early in the nineteenth century.

Land Nationalisation. By Alfred Russel Wallace. 252 pages. Allen & Unwin .. 1s. and 2s. 6d.
A survey of the English land system, and a comparison of the system of landlord and tenant with that of occupying ownership. The effect of the influence of both systems on the welfare of the people is discussed, and land nationalisation is advocated.

Land Nationalisation. By Harold Cox. 238 pages. Methuen .. .. 3s. 6d. net
This little treatise, by an eminent individualist, is an argument against land nationalisation and land taxation, on the grounds—(1) of the ineffectiveness of such methods for the purposes desired; (2) of their injustice; (3) of difficulties in application.

The Adjustment of Wages. By W. J. Ashley. 362 pages. Longmans .. .. .. 12s. 6d. net
A study in the coal and iron industries of Great Britain and America. Gives a survey of existing conditions that help to a solution of the problem. Shows that Americans have something to learn from English conciliation boards, and Britishers something to learn from American "scales," as in machine-minding rates. Deals with the position of organised labour and capitalistic syndicates.

The Factory System. By R. W. Cooke-Taylor. 189 pages. Methuen .. .. 2s. 6d.
A handbook containing a popular statement of how the factory system came to be, and of the controversies which have been waged with regard to it, together with a summary of legislation concerning factories. Contains a list of official forms for use under the Factory and Workshop Acts.

The Effects of Machinery on Wages. By J. Shield Nicholson. 143 pp. Allen & Unwin. 1s. net.
The author wrote as Professor of Political Economy in Edinburgh University, and here discusses machinery in its various aspects in relation to labour—the substitution of machinery for labour; machinery as auxiliary to labour; its effect on the division of labour; its influence in bringing about the concentration of labour and capital, and its effect on the mobility of capital and labour. A book of arguments rather than facts.

Six Centuries of Work and Wages. By J. E. Thorold Rogers. 591 pages. Fisher Unwin. 10s. 6d. net
A master-work on English labour and social conditions, rural and urban, giving a comprehensive view of the whole situation as the author knew it.

Eight Chapters on the History of Work and Wages. By J. E. Thorold Rogers. Fisher Unwin. 2s. 6d. net
A valuable condensation, in a popular form, of the late Professor Rogers's "Six Centuries of Work and Wages," using the facts that have a bearing on present day life. The "Six Centuries" was itself an abridgement of Rogers's most enlightening and painstaking work, in eight volumes, entitled "A History of Agriculture and Prices in England." A mine of information for those who regard history from economic and social standpoints.

Evolution of Modern Capitalism. By J. A. Hobson. 450 pages. Walter Scott .. .. .. 6s.
In this work Mr. Hobson traces the origin of modern capitalism; the instrument by which it works machinery; the structure of industry before machinery; the development of machine industry; the structure of modern business, trades, and markets; combinations of capital; industrial depression; the demand for labour, and the quality of labour; the economy of high wages; and the effects of modern industry on workers as consumers. A clear and well-balanced statement.

Capital. By Karl Marx. English translation by S. Moore and E. Aveling. Glaisher. 10s. 6d.
One of the most famous of all works on economic science, and the basis of many socialist arguments. It consists of a comprehensive critical analysis of capitalist protection and its effects, with a dramatic picture of the irresistible march of capitalism.

Sweating. By Edward Cadbury and George Shann. 145 pages. Headley Brothers .. .. 1s. net
The writers give, in brief yet systematic form, the facts and theories of sweated industries. As they intend the book primarily for working men, they have avoided the use of technical terms. Sweating as practised in the past and as understood at present is defined. The economic cost of it is set forth, causes are traced, and remedies are drafted.

Sweated Industry. By Clementina Black. 281 pages. Duckworth .. .. 2s. net
"Sweating" is applied in this book to any method of work under which the workers are extremely ill paid or extremely overworked. Miss Clementina Black has a remarkable knowledge of the subject, and brings together startling facts respecting "the poorest of all," workers in factories, shop-assistants, clerks, waitresses, traffic workers, and wage-earning children. She also discusses at length the question of a minimum wage.

Money and Its Relation to Prices. By L. L. Price. 200 pages. Allen & Unwin .. .. 1s. net
An inquiry into the causes, measurement, and effects of changes in general prices, with a consideration of the economic effects of these changes, the rise of prices consequent on the discovery of America and other "realms of gold."

Things that Matter. By Sir Leo Chiozza Money, M.P. 299 pages. Methuen .. .. .. 5s. net
A collection of essays on social and economic questions, by a writer of authority with a clear style and an original mind. The aim of the book is to direct attention to the problems and dangers which demand the grave attention of the nation. Deals with wages and industry, prices and the cost of living, education and insurance, emigration and foreign investments.

Riches and Poverty. By Sir Leo Chiozza Money, M.P. 349 pages. Methuen .. .. 5s. net
A scathing indictment of the unequal and unjust distribution of wealth in the British Isles, full of dreadful facts, and offering proposals which, after all, appear inadequate to the evil situation.

Lombard Street. By Walter Bagehot. 359 pages. Smith, Elder .. .. 3s. 6d. net
An account of the money-market and its relations to constitutional and commercial affairs. The money-market, Bagehot affirms, is no impalpable abstraction, but a concrete reality, and must be discussed as such. Banking in commerce, and its basal position in all enterprise, distinguishes modern methods from all previous methods.

Cash and Credit. By D. A. Barker. 143 pages. Illustrated. Cambridge University Press. 1s. net
The writer describes his book as an attempt to give a sketch of the theory of money in its most practical aspect, so as to provide a stepping-stone to more detailed study. He describes cash and credit from the point of view of the counter of a country bank.

Money and the Mechanism of Exchange. By W. Stanley Jevons. 349 pages. Kegan Paul .. 5s.
A descriptive essay on the ancient and modern monetary systems of the world, and the method in which the use of money is immensely economised by the cheque and clearing system now being developed and perfected. Explains the functions of money, the mechanism of exchange, promissory notes, and the means of regulating a paper currency.

For and Against Experiments on Animals. By Stephen Paget. With an Introduction by Lord Cromer. Nisbet .. .. .. 4s. 6d.
Gives a clear account of the chief results obtained during the past thirty years, by the help of experiments on animals, stated, as far as possible, in the very words of the men who did the work. Considers the anti-vivisection evidence, describes the anæsthetics used on animals, and cites the report of inspectors and the report of the Royal Commission.

The Socialist Movement. By J. Ramsay MacDonald. 256 pages. Williams & Norgate .. 1s. net
In this book Mr. Ramsay MacDonald, the recent leader of the Labour Party in the House of Commons, sets out to state clearly and authoritatively what Socialism means, and what its purpose is, and to distinguish it from the many irrelevant theories with which it is often credited. The book contains a valuable classified bibliography.

The Crown of Wild Olive. By John Ruskin. Allen & Unwin .. .. 1s. net
A reprint of lectures pointing out the weaknesses and insincerities of modern society, and developing Ruskin's peculiar tenets of socialistic co-operation and conscience. One of the most simple and eloquent of his books, but with a remarkably ornate introduction, designed, apparently, to influence the conduct of men by sheer oratorical power.

Time and Tide. By John Ruskin. Allen & Unwin .. .. 1s. net.
Elaborating Ruskin's ideas of the place of labour in the world and the responsibilities of riches. Ranking in simplicity and directness of treatment with "The Crown of Wild Olive."

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In all cases the prices in this list are the maximum prices, and in many cases, whether indicated or not, there may be a discount of threepence in the shilling. Almost invariably shilling books, and nearly all technical works, are net.

Unto This Last. By John Ruskin. Allen & Unwin .. .. 1s. net
Four essays on political economy and social organisation contributed to the "Cornhill Magazine," but brought to an end because they were "reprobated in the most violent manner" by the readers.

Progress and Poverty. By Henry George. Kegan Paul .. .. 1s.
An exposition of the single-tax theory on land, for the relief of industry. The author would tax land up to its full economic value, apart from improvement. The book is not an exposition of Socialism, as is generally supposed, but a proposal for a new form of taxation, consistent with individualism.

The Commerce of Nations. By C. F. Bastable. 226 pages. Methuen .. .. 2s. 6d.
Men of the present generation have in many cases forgotten, or never knew, the history of the freeing of trade from hampering restrictions. The writer shows how modern Protectionism has grown and flourished on ideas inimical to true progress.

Land and Labour: Lessons from Belgium. By B. Seebohm Rowntree. .. .. Macmillan. 5s. net
The author has set himself the task of investigating the connection between social conditions and the methods of holding land in various countries, but for the present concentrates on Belgium. There he has studied the main aspects of social and economic life for four years, with the result that the land system is described in detail—industrial questions, with the wages paid, are considered; agriculture is treated at considerable length, with transport facilities, taxation and education; and, further, such subjects as the standard of living, housing, destitution, and unemployment are discussed. An admirable book, full of information.

A History of Factory Legislation. By B. L. Hutchins and A. Harrison. 298 pages. P. S. King .. 6s.
This very useful general sketch of the story of factory legislation, from the days of the Poor Law of Elizabeth to 1910, has deserved and achieved considerable popularity. To the latest edition Mr. Sidney Webb contributes a preface, and briefly retells the story. The coming of the factory system is a phenomenon which every citizen should understand. This book provides the materials.

An Introduction to English Economic History and Theory. By W. J. Ashley. 2 vols. Longmans .. .. 15s. 6d.
Deals with the village community, the merchant and craft guilds, the supremacy of the towns, the agrarian revolution, and the Tudor enclosures. Covers the period from the Norman Conquest to the sixteenth century. An admirable work, introducing the general reader to the study of great natural forces, often neglected in ordinary historical books.

Principles of Political Economy and Taxation. By David Ricardo. Dent .. .. 1s. net
Ricardo, whose work was suggested by "The Wealth of Nations" of Adam Smith, was one of the greatest exponents of the old, orthodox political economy.

The Subjection of Women. By John Stuart Mill. 128 pages. Longmans .. .. .. 6d. net
The first formal examination of the relations between men and women in public life, leading up to the theory that absolute equality should exist in all civic and national respects. While the abstract argument remains the same, the illustrative circumstances of disparity between the sexes—particularly in legal respects—has been considerably varied in favour of women since the book was written.

Political Economy. By S. J. Chapman. 253 pages. Williams & Norgate .. .. .. 1s. net
The beginner could not consult a better introduction to the science of economics. Though thoroughly scientific, it is free from technicalities. There is a small bibliography.

The Wealth of Nations. By Adam Smith. Cheap editions .. ..
The book on which the modern science of political economy is based, though some of Smith's views have been effectually controverted. The book overthrew entirely the mercantile system which supposed that nations could enrich themselves by shutting off foreign trade and hoarding gold. It proved that wealth came by the interchange of the products each country could most suitably bring into the world's general market.

The Science of Wealth. By J. A. Hobson. 256 pages. Williams & Norgate .. .. 1s. net
Mr. Hobson, a prolific writer on concrete social and economic questions, here studies "the structure and working of the modern business world in which wealth is made and distributed as income." The work is in close touch with actual conditions.

Industrial Democracy. By Sidney and Beatrice Webb. 929 pages. Longmans .. .. 12s. net
Contains a mass of facts on the labour question in all its aspects, gathered by the authors from personal investigations. The organisation and importance of the labour movement are admirably described.

Life and Labour of the People of London. By the Rt. Hon. Charles Booth. 17 vols. Macmillan. .. ..5s. net per vol.
An important investigation of the conditions of life and labour in London, issued during the years 1892 to 1903. Mr. Booth was assisted by many devoted workers, and the whole area was examined with astonishing minuteness. In this work appeared first an economic classification of the population which has since been used by Mr. Rowntree and others—viz., class A, lowest class; B, irregular work; C, intermittent earnings; D, small regular earnings; E, standard earnings, the latter including artisans of all kinds; F, best paid artisans and foremen; G, lower middle, including small shopkeepers and clerks; and H, including those who keep servants. It was found that about 30 per cent. of the population were in poverty (classes A-D), and about 70 per cent. in comfort (classes E-H).

The Psychic Factors of Civilisation. By Lester F. Ward. 369 pages. Ginn .. .. 8s. 6d. net
An evolutionary tracing of the age-long advance in psychic processes to a culmination in social action, in which society will attain a collective consciousness, find its soul, and establish sociocracy as a form of government.

Garden Cities of Tomorrow. By Ebenezer Howard. 167 pages. Illustrated. Allen & Unwin. 1s. net
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Rural England. By H. Rider Haggard. Two vols. Longmans .. .. 12s. net
An account of agricultural and social researches carried out in 1901 and 1902. A most valuable document on the condition of the country-side, full of facts bearing on the chief problem of modern English life. Here is an arsenal of facts for all interested in the resurrection of British peasantry.

Life in an English Village. By Maud F. Davies. 319 pages. Fisher Unwin .. .. 10s. 6d. net
An account of the conditions of life in a typical small parish in Wiltshire. The social, economic, and moral aspects are dealt with, and the causes of poverty examined. The book also contains a sketch of the history of the village. A most interesting work for social students.

The English Village Community. By Frederic Seebohm. 453 pages. Illus. Longmans. 4s. 6d. net
A historical survey of the old land systems of England, showing the prevalence of the open-field system throughout Great Britain in the Middle Ages, and describing the manorial system, the tribal system, and various local systems; also tracing the development of serfdom out of the manorial system. A valuable book for the student of social life.

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Fields, Factories, and Workshops. By Prince Kropotkin. 477 pages. Nelson .. 1s. net
Discusses the advantages which civilised societies could derive from a combination of industrial pursuits with intensive agriculture, and of brain work with manual work. The decentralisation of industries, together with the development of agriculture, is put forward as the most hopeful path to social progress. Perhaps an over-optimistic point of view.

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A study of the elements of historical and practical politics, by the man who presides over the American people. The work is worthy of a great scholar and statesman, and is interesting to all nationalities.

The City of the Sun. By Thomas Campanella. 46 pages. Routledge .. .. 1s.
In this Italian outline of a fanciful State, the place is pictured as being "immediately under the equator," but where is not indicated. The writing is largely symbolical or allegorical, and has not the air of reality of More's "Utopia."

The Condition of England. By C. F. G. Masterman. 225 pages. Methuen .. .. .. 1s. net
An extremely interesting study of the people of England at the present day. Gives a most convincing picture of the real inner life of the various classes: the wealthy; the middle classes; the artisans; the very poor. A book to be read by all social students. Points out the real direction in which hope lies for the future.

Looking Backward. By Edward Bellamy. Cheap editions.
A story of an ideal future social State, in America, into which a hypnotised sleeper wakes when Capital and Labour have settled their accounts, and have come to an agreement that gives everybody the work and reward suitable for him. This communistic city looks back on our age of competition and warring interests as on days of savagery.

The Nemesis of Nations. By W. Romaine Paterson. 348 pages. Dent .. .. .. 10s. 6d. net
The author holds that slavery was the foundation of ancient states, and his book deals with the law of slavery as the first law of nations, namely, "that masters have the power of life and death over slaves, and whatever the slave earns he earns for his master."

The Greek Commonwealth. By Alfred E. Zimmern. 452 pages. Clarendon Press .. .. 8s. 6d. net
An attempt to show clearly what Athens was really like in the fifth century before Christ. With full knowledge and keen insight the author discusses the elements of citizenship as understood in ancient Greece, the economics of town and country, and the problems introduced by extending enterprise and power. A scholarly, thoughtful, sympathetic book.

Betting and Gambling: A National Evil. By B. S. Rowntree. 262 pages. Macmillan .. .. 6d.
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The Criminal. By Havelock Ellis. 357 pages. Illustrated. Walter Scott .. .. .. 6s.
A critical summary of the results of the science now known as criminal anthropology, or the study of the criminal as he is in himself, and as he becomes in contact with society. The author has brought together a large amount of evidence which has been collected in regard to the physical and psychical characteristics of criminals. The author deals with the treatment of criminals, and shows that intellectual education is of no value; physical and moral education, and such training as will enable a person to play a part in social life, are needed.

Crime and Insanity. By C. A. Mercier. 254 pages. Williams & Norgate .. .. .. 1s. net
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Temperance Progress of the Nineteenth Century. By J. G. Woolley and W. E. Johnson. Chambers. 5s.
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Child Labour in the United Kingdom. By Frederic Keeling. P. S. King .. .. .. 7s. 6d.
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Parenthood and Race Culture : an Outline of Eugenics. By C. W. Saleeby. Cassell. 7s. 6d. net
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Heredity and Eugenics. By J. M. Coulter and others. 312 pages. Illus. Cambridge Univ. Press 10s.
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The Right of the Child to be Well Born. By George E. Dawson. Funk & Wagnalls .. .. 3s.
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Labour and Childhood. By Margaret McMillan. 205 pages. George Allen & Unwin .. 3s. 6d.
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Outlines of Zoology. By J. Arthur Thomson. 875 pages. Illustrated. H. Froude .. 12s. 6d.
A manual for students. Gives a general survey of the animal kingdom, discusses in detail the structures and functions of animals, and the forms of vanished life recorded in the rocks and sands. Deals with the doctrine of descent, and then examines each order of animal life from the minute one-cell organism to man.

Animal Life: Its Natural Conditions of Existence. By Karl Semper. Illustrated. Kegan Paul. 5s.
The author enters upon an investigation of how variability in animal organisms is brought about by their surroundings. First he deals with inanimate surroundings—food, light, temperature, water at rest and in motion, atmosphere at rest and in motion—and then he considers living surroundings—the influence of living organisms on life and structure.

The Colours of Animals, Their Meaning and Use. By E. B. Poulton. Illustrated. Kegan Paul 5s.
Treats more particularly of the colours of insects. Shows the utility of colour and marking in animals, and gives reasons for supposing that the results have mainly been achieved by natural selection in the struggle for life. Protective resemblances, aggressive resemblances, warning colours and protective mimicry, and courtship colours are discussed.

Industries of Animals. By Frederick Houssay. 258 pages. Illustrated. Walter Scott .. 3s. 6d.
A book of fact which rivals fiction, describing the marvellous activities in humble creation, with chapters on animals that hunt, fish, and go to war; animals that provision themselves against rainy days, and build up societies; animals which make ingenious dwelling-places, and carry out defensive and sanitary work.

Animal Locomotion: or, Walking, Swimming, and Flying. With a Dissertation on Aeronautics. By J. Bell Pettigrew. Kegan Paul .. .. 5s.
Explains in simple language some of the difficult problems in animal mechanics—how legs move by the force of gravity; the locomotion of horse, ostrich, and man; the swimming of animals and fishes, and the action of the wings of birds and bats. Has a chapter on the balloon, on artificial wings, and the nature of the forces required to propel them.

Animal Intelligence. By George J. Romanes. 498 pages. Kegan Paul .. .. 5s.
One of the classics of the Darwinian theory. Deals with the animal mind from the point of view of evolution, and in connection with the growth of the human faculties. Begins with the lowest animals, treats of insects, fishes, reptiles, birds, and mammals, and the domesticated beasts. Interesting and clearly written book.

Animal Mechanism. By E. J. Marey. 283 pages. Illustrated. Kegan Paul .. .. .. 5s.
A pioneer work by a master-hand, who designed the instruments by which his discoveries were made. Marey applied the new method of instantaneous photography to the study of galloping horses and running men. He measured the wing-beats of insects by the sounds they made, and examined the muscular efforts that produced the to-and-fro movements of their wings.

The Mason Bees. By J. Henri Fabre. Hodder & Stoughton .. .. 6s. net
This volume contains not only all Fabre's essays on the Mason Bees, but also some miscellaneous papers—as, for example, one on cats—so as to make the edition of the works of Fabre published by Messrs. Hodder & Stoughton thoroughly representative.

The Life of the Fly. By J. Henri Fabre. Hodder & Stoughton .. .. 6s. net
The translator, Alexander Teixeira de Mattos, has followed in the most admirable way the simplicity of style which gives the works of the naturalist Fabre such a charm. A delightful rendering of a delightful book.

Billy and Hans. By W. J. Stillman. Bell. 1s. net
A pretty study of two squirrels, one genial and the friend of man, the other morose, but the friend of Billy. When Billy died, Hans grew confidential, and took his place in his master's pocket. A sympathetic and convincing sketch.

The Romance of the Animal World. By E. Selous. 330 pages. Illustrated. Seeley .. .. 5s.
A popular study of the ways of many animals, great and small, written in a very anthropomorphic spirit, but showing much observation and sympathy. Snails, crabs, caterpillars, ants, wasps, birds, snakes, beavers, crocodiles, whales—even the sea-serpent—all have their place.

The Romance of Animal Arts and Crafts. By H. Coupin and John Lea. Illustrated. Seeley.. 5s.
In this book the activities of wild animal life are described as a fairy version of human industry—as the spinning, weaving, sewing, manufacture of paper and pottery, aeronautics, raft-building, road-making, etc., of animals, birds, and insects.

Natural History of Selborne. By Gilbert White.
A charming record of the observation of all kinds of natural happenings in bird-life, plant-life, weather, etc., within a very narrow range, from year to year. The chief use of the book now is its stimulation of the spirit of observation, and its incitement to the keeping of exact records.

The Infancy of Animals. By W. P. Pycraft. 272 pages. Illustrated. Hutchinson .. 6s. net
A scientific treatise, in popular language, of the appearance and habits of the young of a very large number of animals, birds, reptiles, and fishes; of great interest to the student of evolution, the observer of Nature, and for the general reader. The problems of coloration, the ways in which the young are carried, fed, and instructed, their growth and development, and many other interesting facts, are treated of.

Peeps into Nature's Ways. By J. J. Ward. 320 pages. Pitman .. .. 3s. 6d. net
A capital book for students of minute forms of life, including both insects and plants. The illustrations include a large number of micro-photographs taken by the author, one of the chief photographic contributors to the pages of the SELF-EDUCATOR.

The Naturalist in Nicaragua. By Thomas Belt.
The author, one of the greatest of practical observers of last century, travelled over many parts of the world, gold-mining, and at the same time noting the wild life of the regions where he lived. In this book he gives a true and living account of the snakes and birds and strange insects of this part of Central America, where he was stationed for four years. There is no ornate language in his book, but it is vivid and full of colour.

The Horse and Its Relatives. By R. Lydekker. 286 pages. Illustrated. Allen & Unwin. 10s. 6d. net
A popular and yet scientifically accurate account of the natural history of the more important representatives of the horse family. Deals with the wild tarpan, the extinct forerunners of the horse, the wild ass, zebra and quagga, and the model types of horse. Written in an interesting way, and suitable for the general reader.

The Naturalist on the Amazons. By H. W. Bates.
The author of this classical work was a friend of Charles Darwin and of A. R. Wallace, and it was with the latter that the famous expedition to the Amazons was planned and carried out. Both were keen naturalists, and Bates, who remained eleven years on the banks of the Amazons, collected in that time an enormous number of insects, some eight thousand of which were previously unknown to science.

Curiosities of Natural History. By Frank Buckland. Four vols. Macmillan .. .. 2s. 6d. each
Four delightful volumes, the outcome of many years of intimate observation.

The Seashore. By W. S. Furneaux. 454 pages. Illustrated. Longmans .. .. 3s. 6d. net
A very useful book by a writer who is skilful in displaying knowledge in an inviting way. It gives just the kind of guidance needed for those who are starting the study of the wonders of the sea's margin. Abundantly illustrated.

Life by the Seashore. By Marion Newbigin. 344 pages. Illustrated. Allen & Unwin. 2s. 6d. net
This book is written with an attractive simplicity. Its object is to enable those who have had no special zoological training to learn the names and the characters of the common inhabitants of the sea-shore pools.

An Outline of the Natural History of Our Shores. By Joseph Sinel. Illustrated. Allen & Unwin. 7s. 6d.
An addition to the title is "with chapters on collecting and preserving marine specimens, methods of microscopic mounting, and on the marine aquarium." The descriptions, covering a wide field, are chatty and easily understood, and the illustrations are excellent.

Life in the Sea. By J. Johnstone. 150 pages. Illustrated. Cambridge University Press. 1s. net
The investigation of the microscopic life of the sea has reached a point where it is worth while to make broad surveys of the life of the ocean, to consider how the different kinds of organisms affect each other, and how they are influenced by the great seasonal changes that sweep across the sea. Such a discussion of the general economy of the sea is attempted in this book.

Fresh-water Aquaria. By G. C. Bateman. 350 pages. Illustrated. Upcott Gill .. .. .. 3s. 6d.
A profusely illustrated handbook, dealing with the construction, arrangement, and management of aquaria, with descriptions of suitable water-plants and live-stock, and how to obtain them.

British Mammals. By Sir Harry Johnston. 405 pages. Illustrated. Hutchinson .. 12s. 6d. net
This handsome volume, most beautifully illustrated with coloured plates and with drawings and photographs, forms one of the series of natural history volumes of the Woburn Library, edited by the Duke of Bedford. It includes an account of the mammals of Britain from pleistocene ages to the present day.

The Mammalia in Their Relation to Primeval Times. By Oscar Schmidt. Illustrated. Kegan Paul. 5s.
A study of the mammalia in their relation to palæontology and anthropology. After discussing the distinctive characteristics of the mammals and their position in the animal kingdom, Professor Schmidt divides them, in a comparison of the living animals with their ancestors, into forked animals, marsupials, animals poor in teeth, hoofed animals, pair-hoofed animals, odd-hoofed animals; and then follows miscellaneous lines up to man, and the man that is to be.

An Introduction to the Study of Mammals. By W. H. Flower and R. Lydekker. Black. 12s. 6d.
A comprehensive book for students, covering mammals living and extinct, and entering into considerable detail in a number of selected members of the order. It contains a copious bibliography.

A Book of Whales. By F. E. Beddard. 320 pages. Illustrated. John Murray .. .. 6s. net
A comprehensive account of the cetacea, giving the main facts of their structure and mode of life, and especially dwelling on the intimate relation between structure and environment—a biological generalisation that is shown in the whales in a striking degree.

The Horse : a Study in Natural History. By W. H. Flower. Illustrated. Kegan Paul .. 2s. 6d.
Discusses the place of the horse in Nature, and its ancestors and relatives. Examines the structure of the horse in its bearing upon its manner of life, its evolution, and relation to other animal forms. A good example of a work popular yet scientific.

The Ox and Its Kindred. By R. Lydekker. 271 pages. Illustrated. Methuen .. .. 6s.
Gives the history of the extermination of the great wild ox of Europe and Asia. Deals with the so-called white wild cattle of British parks, and the humped cattle of Asia and Africa ; but the main theme is the domesticated breeds of ancient and modern times. Sound and clear.

The World's Birds. By F. Finn. 180 pages. Illustrated. Hutchinson .. .. .. 5s. net
A practical and comprehensive classification of living birds, the description of each family being fully elaborated under the headings—diagnosis ; size ; form, plumage, and coloration ; young ; nest ; eggs ; incubation ; food ; gait ; flight ; note ; disposition and habits ; economic qualities ; captivity ; distribution and species.

A History of Birds. By W. P. Pycraft. 458 pages. Illustrated. Methuen .. .. 10s. 6d. net
An excellent work, written from the point of view of the evolutionist, surveying the evidence bearing on the birth and growth of various types of birds, and presenting the study of a bird as one of the living organisms moulded in part by an inherent constitution, and in part by the struggle with environment.

A Handbook of British Birds. By J. E. Harting. 551 pages. Illustrated. Routledge .. £2 2s.
Shows the distribution of the resident and migratory species of birds in the British islands, and gives a record of the rarer visitants. Contains in a single volume, enriched with 35 coloured plates, the precise status of every British bird, and, according to the author, conveys information of a kind not to be found in any other work on British birds.

British Birds. By W. H. Hudson. Illustrated. Longmans .. .. 3s. 6d. net
The best cheap English book on British birds, written by a master of pure English, and a most competent and sympathetic observer.

British Birds in Their Haunts. By C. A. Johns. Routledge .. .. 7s. 6d. net
An admirable work brought up to date, and embellished with 64 coloured plates. Contains a glossary of common and provincial names and technical terms. Many delightful stories and descriptions of the daily life of birds.

The Romance of Bird Life. By John Lea. 376 pages. Illustrated. Seeley .. .. .. 5s.
A popular study of the courtship, fighting, education, sports, toilet, migration of birds, and even their wisdom and follies.

British Birds and Their Eggs. By J. M. Boraston. Coloured illustrations. Chambers .. .. 6s. net
This book, containing a new method of identification, is written for the beginner, so that he may recognise any bird from its most obvious characteristics, such as broad distinctions of colour, markings, gestures, and song.

Britain's Birds and Their Nests. By A. L. Thomson. Coloured illustrations. Chambers .. 21s. net
A delightful book, dealing with all the birds of our country in their respective orders and families. The coloured drawings have been made by Mr. George Rankin from close observation of the birds and their eggs and nests.

Eggs and Nests of British Birds. By F. Finn. 231 pages. Illustrated. Hutchinson .. 5s. net
An excellent and comprehensive manual of pocket size, including coloured reproductions of 154 eggs from nature, in 20 plates, reproductions of 74 eggs in half-tone, and other illustrations. Useful for the collector, and very reliable.

Birds of the Countryside. By F. Finn. 186 pages. Illustrated. Hutchinson.. .. .. 5s. net
With 12 coloured plates, 118 photographs, and many outline drawings, this little pocket manual is useful to anyone who wishes to be able to identify British birds.

The Migration of Birds. By T. A. Coward. 130 pages. Maps. Cambridge University Press. 1s. net
A fascinating subject is treated in this book in a common-sense manner by a modest author. In commenting on routes used in migration, several maps are given. Much attention is paid to the effects of wind and weather on bird flights.

Reptiles of the World. By Raymond L. Ditmars. 391 pages. Illustrated. Pitman .. 20s. net
The photographs, by the curator of reptiles in the New York Zoological Park, give this book unique value. The work is at once popular and scientific, and includes tortoises, turtles, crocodiles, lizards, and snakes as observed in many parts of the world.

Reptile Life. By W. P. Pycraft. 208 pages. Illustrated. Hodder & Stoughton .. .. 1s. net
The author begins by distinguishing between a true reptile and such "amphibia" as frogs, toads, etc. The form and habits of some of the most interesting reptiles, such as lizards, tortoises, crocodiles, geckos, chameleons, snakes, are described in detail.

British Serpents. By Gerald Leighton. 383 pages. Illustrated. Blackwood .. .. .. 5s. net
A book of great value. The only volume entirely devoted to the life history and local distribution of the native British serpent. Largely illustrated from photographs.

British Lizards. By Gerald Leighton. 214 pages. Illustrated. Upcott Gill .. .. .. 5s.
The author is an eminent authority on his subject, and this book, dealing with lizards in every county, is the only volume devoted solely to the life history and local distribution of British lizards.

An Introduction to the Study of Fishes. By A. C. L. G. Gunther. 736 pages. Illus. Black .. 12s. 6d.
Gives in a concise form an account of the principal facts relating to the structure, classification, and life history of fishes. A useful book of reference.

Origin and Metamorphoses of Insects. By Lord Avebury. Illustrated. Macmillan .. 3s. 6d.
An introduction to the life history of insects, by the well-known naturalist, banker, and statesman, written with all the charm which he always found in Nature-study. Many clear line-drawings illustrate the text.

Natural History of British Fishes. By Frank Buckland. Illustrated. S.P.C.K... .. 3s. 6d. net
A book for the general reader, giving an account of the structure and economic uses of British fishes, and their capture by net and rod, with many useful hints both to sea and fresh-water fishermen. Methods of fish-culture in ponds and hatcheries are described.

British Fresh-Water Fishes. By Sir Herbert Maxwell. 316 pages. Illustrated. Hutchinson. 5s. net
Another of the handsome series edited by the Duke of Bedford. The British species, which number only about fifty out of a vast variety now known to science, are described, for sake of accuracy, in scientific terminology, and afterwards with all the interesting details gathered by an expert observer. The descriptions are full of interest, and the coloured plates beautiful.

British Salt-Water Fishes. By F. G. Aflalo. 328 pages. Illustrated. Hutchinson .. 12s. 6d. net
Another of the handsome natural history books edited by the Duke of Bedford, and illustrated with very fine coloured plates. The author gives a scientific account of the salt-water fishes which can be described as British, summarising their habits and appearance, their distribution, and their migrations. As is here pointed out, the study of life in the seas has a practical bearing on British industrial supremacy.

The Fresh-Water Fishes of the British Isles. By C. T. Regan. 312 pages. Illus. Methuen 6s.
A popular account of the fishes of our lakes and rivers, their characters, geographical distribution, and life history. The most recent researches, such as those on the growth and migrations of the salmon, and on the life and history of the eel, are explained in a lucid and arresting manner.

Insects : Their Structure and Life. A Primer of Entomology. By G. H. Carpenter. Dent 4s. 6d. net
A small, cheap book, sketching in outline the whole subject of the study of insect life. Gives the life history of insects. Traces their relationship, the origin of wings, and metamorphosis.

Insect Life: Souvenirs of a Naturalist. By J. H. Fabre. 320 pages. Illus. Macmillan .. .. 2s. 6d.
One of the classics of modern science, by a master naturalist with a fine talent for literature. Introduces the reader into the strange, weird, wonderful world of insect life, some of the secrets of which it has taken Dr. Fabre a long life of constant, intense observation to discover. Unequalled for studies of living insects whose instincts are best developed.

The Life and Love of the Insect. By J. H. Fabre. 262 pages. Black .. .. 5s.
The author was all his life a keen and minute observer of the habits and manners of insects, and was, without doubt, the greatest entomologist of our times. This smaller work, which is a selection from his famous "Souvenirs Entomologique," is at once eminently scientific and extremely fascinating.

Insect Wonderland. By Constance M. Foot. 196 pages. Illustrated. Methuen .. 3s. 6d. net
A volume of simple facts concerning the insect world, dealing with representatives of the seven great orders of insects. Suitable for reading by children, for pleasure and information.

House-Flies. By C. G. Hewitt. 122 pages. Illustrated. Cambridge University Press .. 1s. net
A well-written and illustrated handbook on the structure and habits of the house-fly, and especially on the part it plays in the spreading of disease.

Insect Life. By F. V. Theobald. 235 pages. Illustrated. Methuen .. .. 2s. 6d.
A cheap, sound, and concise account of the classification and habits of insects. Deals with their metamorphosis and structure, and then describes in a broad, brief way the characters of the various orders. Has an appendix on insecticides.

The Romance of Insect Life. By Edmund Selous. 350 pages. Illustrated. Seeley .. .. 5s.
Interesting descriptions of the strange and curious in the insect world, including many kinds of ants and their remarkably ingenious customs, caterpillars, spiders, aquatic insects, scorpions, etc.

A Textbook of Entomology. By Alpheus S. Packard. 729 pages. Illustrated. Macmillan. 19s. net
A comprehensive work by an American author, designed for the use both of students and teachers. "The aim has been to afford a broad foundation for more special work by anyone who may want to study some group of insects." The chapters' headings are: Morphology and Physiology, Internal Anatomy, Embryology, and Metamorphosis.

British Insects. By E. F. Staveley. 407 pages. Illustrated in colours. Lovell Reeve. 7s. 6d. net
A practical book for the use of observers of insects, describing the form, structure, habits, and changes of the principal British examples. Excellently illustrated by coloured plates.

Our Insect Friends and Foes. By F. Martin Duncan. 296 pages. Illustrated. Methuen .. .. 6s.
This highly interesting book not only describes numerous forms and habits of insect life, but also points out vividly their bearing upon human health and prosperity. Chapters deal with insect communities; aquatic insects; insect actors; insects in commerce; poison-fang and stiletto; insects and flowers; our beetle friends; our insect foes—ravagers of crops and transmitters of disease. The plates are very good.

The British Lepidoptera. By Richard South. Three vols. Illustrated. Warne .. .. 21s. net
The illustrations are the most beautiful and realistic pictures of moths that could possibly be produced. Some of them, cut out and mounted in a glass case, are practically indistinguishable from actual specimens. Of immense value to practical entomologists. The volumes are also sold separately: The Butterflies of the British Isles, 6s. net; The Moths of the British Isles, 6s. net each.

Butterflies and Moths of the Countryside. By F. E. Hulme. 300 pages. Illus. Hutchinson. 8s. 6d.
This large and handsome volume has thirty-five coloured plates by the author, showing many different species. The text describes the appearance, life-history, and localities of British moths and butterflies.

British Dragonflies. By W. J. Lucas. 350 pages. Illustrated. Upcott Gill .. .. 10s. 6d.
A beautiful book on the life-history, species, and varieties of our dragonflies, with remarks on their capture and preservation. An exhaustive treatise, adorned with 27 carefully printed plates in colour, with engravings in the text.

The Dispersal of Shells. By Harry Wallis Kew. 291 pages. Illustrated. Kegan Paul .. .. 5s.
Dr. Alfred Russel Wallace, in a preface to this book, says that many books of far greater pretension, even though they contain descriptions of scores of new species of shells, may be of less interest than this general summary of dispersal. The writer has gathered his facts with great industry, and writes a first book with modesty.

The Lore of the Honey-Bee. By Tickner Edwardes. 196 pages. Methuen .. .. .. 1s. net
An instructive and entertaining little book on the life of the bee community, with a gleaning of old beliefs and stories concerning bees, and an account of some bee-farms of today.

The Life of the Bee. By Maurice Maeterlinck. 344 pages. Allen & Unwin .. .. 2s. 6d. net
A sympathetic and imaginative study of bee life and work, including many profound if somewhat hazy meditations on nature, instinct, destiny, etc. The book has great literary value.

The Honey-Bee. By T. W. Cowan. 220 pages. Illustrated. Houlston .. .. .. 2s. 6d.
This admirable manual on the natural history, anatomy, and physiology of the bee is by the editor of the "British Bee Journal." The book is purely scientific, not a guide to bee-keeping.

Shell Life. By Edward Step. Illus. Warne. 6s.
An introduction to the British mollusca, with 32 plates photographed from the actual shells, and upwards of 300 figures in the text. A useful volume for all who wish to know something of the common objects of the seashore. The information is arranged on a scientific basis, not too technical.

Earthworms and Their Allies. By F. E. Beddard. 143 pages. Cambridge University Press. 1s. net
Mr. Beddard introduces first the anatomical structure of the worm, describes its mode of life, discusses the relative frequency of earthworms in different regions of the world, and traces their movements and migrations. His survey includes nearly all the usually admitted genera. The literature of the subject is included under geographical divisions.

The Life of Crustacea. By W. T. Calman. 305 pages. Illustrated. Methuen .. .. 6s.
Gives an account of the wonderfully diversified habits and modes of life of the large division of the animal kingdom that includes lobsters. Addressed to the general reader, in non-technical language.

The Crayfish. By T. H. Huxley. 371 pages. Illustrated. Kegan Paul .. .. 5s.
In this careful study of one of the commonest and most insignificant of animals, Professor Huxley takes the reader from matters of everyday knowledge to the widest views and most difficult problems in the study of life. It is an admirable introduction to zoology.

Jelly-Fish, Starfish, and Sea-Urchins: Being a Research on Primitive Nervous Systems. By G. J. Romanes. 323 pages. Kegan Paul .. 5s.
A book that made the author famous. He shows that the nervous tissue first appears on the scene of life with the qualities it displays in the higher animals. Proved the sense of smell in starfish, by keeping some of these animals without food and then putting small pieces of food near them.

The Foraminifera. By Frederick Chapman. 354 pages. Illustrated. Longmans .. 9s. net
A concise account of the foraminifera, suited to the requirements of the student of natural history and palæontology, and bringing knowledge of the life-history of this and other groups of protozoa and their geographical distribution up to date.

The Protozoa. By Gary N. Calkins. 363 pages. Illustrated. Macmillan .. .. 12s. 6d. net
A summary of the most recent discoveries concerning the minute lower animals. Has an historical sketch of this branch of microscopic science; deals with the organs and functions and structure of the minute animals found in the dust of the air, in the sea, in ditches, in fresh waters and drinking waters, and in the bodies of the higher plants and animals.

British Spiders. By E. F. Staveley. 295 pages. Illustrated in colours. Lovell Reeve. 7s. 6d. net
A well-illustrated book, enabling the reader to identify the different examples of the spider tribe found in Great Britain and Ireland, and to begin their study under competent guidance.

Spiders. By C. Warburton. 136 pages. Illustrated. Cambridge University Press .. 1s. net
This book is concerned with the habits and modes of life of the spiders which are most frequently met with and most easily recognised, and considerable stress is laid on the methods of research by which our modern knowledge of spiders has been obtained. The book is written with clearness and energy.

Animal Parasites and Messmates. By P. J. van Beneden. 274 pages. Illus. Kegan Paul. 5s.
A book of the romances of the minute. The author, a professor at Louvain, who believes boldly in God-given instinct, treats animals first as messmates, then as "mutualists," and last as parasites. The parasites are either free during their own life, or while young, or when old, or they undergo metamorphoses, or they are parasites all their life long. In any case, they are interesting companions as introduced by Professor Beneden.

Plant-Animals. By F. Keeble. 163 pages. Illustrated. Cambridge University Press. .. 1s. net
The plant-animals here discussed are two marine worms. Their nature and behaviour, as observed on the coast of Brittany, are discussed with minuteness after exhaustive observation.

Anecdotes of Dogs. By E. Jesse. Woodcuts and Engravings. Bell .. .. 5s.
A quaint, old-fashioned book of the middle of the nineteenth century, with many illustrations of faithful dogs—some by Bewick.

The Snakes of Europe. By G. A. Boulenger. Methuen .. .. 5s.
This is a strictly scientific book, giving in a concise form an account of the snakes of Europe, their characters, distribution, and life-histories, preceded by an introduction summarising what is known of snakes generally. The author claims that there is no similar work in English.

BACTERIOLOGY

Bacteria and Their Products. By G. S. Woodhead. 459 pages. Illustrated. Walter Scott 3s. 6d.
An account of the main facts in bacteriology and the life history of bacteria and closely allied organisms, with a discussion of the most important theories as to the part that they play in Nature's economy, especially in their relation to the various fermentative, putrefactive, and disease processes.

The Bacteriology of Milk. By Harold Swithinbank and Sir George Newman. John Murray. 25s. net
Sir George Newman is Chief Medical Officer of the Board of Education, and has special chapters on the spread of disease by milk and the control of the milk supply. There is no better textbook for students of the science of public health, and this book should be part of the stock-in-trade of dairyman and medical officer. A work of national value.

Tropical Diseases. By Sir Patrick Manson. 896 pages. Illustrated. Cassell .. .. 12s. 6d.
A manual of the diseases of warm climates, by the discoverer of the fact that some of the most dreadful maladies of tropical countries are communicated by mosquitoes and other insects. Intended principally for travellers and settlers, but forms a handy survey of the whole field of tropical diseases. Shows how the white races are at last obtaining control of the tropics. A chapter in the story of civilisation.

Bacteriology and the Public Health. By Sir George Newman. 497 pp. Illus. John Murray. 21s. net. Dr. Newman, the Chief Medical Officer of the Board of Education, here writes with the object of supplying what is necessary for the student of hygiene and the officer of health to know concerning everyday problems of sanitation and preventive medicine. A most valuable book.

Bacteria in Relation to Country Life. By J. G. Lipman. 486 pages. Illus. Macmillan. 6s. 6d. A discussion of the character of bacteria in rural conditions, with a view to solving many practical problems on the farm. Technical terms and expressions are omitted as far as practicable. Deals with purity of water-supply; bacteria and sewage, and soil fertility; and with bacteria in milk.

Our Secret Friends and Foes. By Percy Faraday Frankland. Illustrated. S.P.C.K. .. 3s. A popular description, by the Professor of Chemistry in the University of Birmingham, of bacteria, and of recent progress in the science of bacteriology. As the title suggests, the book deals with bacteria in relation to human life.

Germ Life : Bacteria. By H. W. Conn. 212 pages. Illustrated. Hodder and Stoughton .. 1s. net. Recognising that bacteria are generally regarded only as agents of disease, the author has here given a wider and more balanced view of the subject. He shows that these organisms "are to be regarded not primarily in the light of enemies, but as friends." The subject is ably treated in popular language.

Household Bacteriology. By E. D. and R. E. Buchanan. 536 pages. Illus. Macmillan. 10s. Intended primarily for students in domestic science. Points out the relation between a knowledge of bacteria and the preparation and preservation of food, household sanitation, and personal hygiene. The book is really an elementary but broad survey of the science of microbe activities, with the various affairs of the household as pegs on which to hang the discussion.

Bacteria, Yeasts, and Moulds in the Home. By H. W. Conn. 293 pages. Illustrated. Ginn. 4s. 6d. An exceedingly interesting and useful little book, providing a scientific basis for home economy. It treats of moulds and the decay of fruit; of yeasts and their uses in fermentation of bread and of liquors; of bacteria and the preservation of food by various methods; of disease bacteria and safeguards against contagion; and of many important subjects of kindred interest.

Outlines of Bacteriology. By David Ellis. 262 pages. Illustrated. Longmans .. 7s. 6d. net. This book is written more particularly for the use of students of technical and agricultural bacteriology; but it will also serve as an introduction to all branches of the subject. The aim has been to demonstrate the fundamental principles underlying the technical application of bacteriology, but matters of theoretical interest have also been introduced, because the science is in a stage when theoretical extension and investigation are highly important. A remarkably comprehensive work.

Bacteria as Friends and Foes of the Dairy Farmer. By W. Sadler. 112 pages. Illus. Methuen. 1s. 6d. A clearly written, practical work on useful and dangerous microbes connected with the dairy industries. Discusses "starters" in cheesemaking and butter-making; troubles in milk production; disease germs and milk, and the necessity for disinfecting dairies and utensils. Shows how to establish a standard quality by the scientific control of the acid germs.

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The Story of the Comets. By G. F. Chambers. 256 pages. Illustrated. Clarendon Press. 6s. net The best popular account of comets and meteors, dealing with every aspect of the subject. A good bibliography.

The Stars. By G. F. Chambers. 192 pages. Illustrated. Hodder & Stoughton .. 1s. net A popular introduction to the stars, their brilliancy and distance, number, movements, and relations with one another, and to all the varieties of stars and nebulæ now known; for those, especially, who do not so far know them. The author tells of double stars, coloured stars, temporary stars, variable stars, groups of stars, clusters of stars, nebulæ, the Milky Way, and, finally, of the stars and nebulæ as known to the spectroscope. A table of the constellations is given in the appendix, as also a list of objects to be seen in small telescopes.

Mars and its Canals. By Percival Lowell. 384 pages. Illustrated. Macmillan .. 10s. 6d. net This popular work gives the history of discoveries with regard to Mars, which have followed one another from 1840 to the present day; describes the chief surface features of the planet, such as the polar caps, and discusses its probable climate. One half of the book is devoted to the "canals," which Mr. Lowell believes to be watercourses surrounded with vegetation. He brings forward strong evidence that these are the work of intelligent beings.

Through the Telescope. By Rev. J. Baikie. 292 pages. Illustrated. Black .. .. .. 5s. An excellent introduction to astronomy, with special reference to practical study of the heavens with small and inexpensive telescopes. The language is simple, and the book is intelligible throughout to any person of ordinary education. The illustrations represent for the most part the results of the best modern instruments, but a few are included to show the work of small telescopes.

The Meteoritic Hypothesis. By Sir Norman Lockyer. 559 pages. Illustrated. Macmillan. 17s. net Contends that many so-called stars are swarms of meteorites, and that all self-luminous bodies in the celestial spaces are composed either of swarms of meteorites or of masses of meteoritic vapour, produced by heat, while many solar phenomena are produced by the fall of meteorites upon the surface of the sun.

Man's Place in the Universe. By Alfred Russel Wallace. 341 pages. Chapman & Hall. 6s. An unorthodox book by a great man, contending that the earth holds practically a central position in the universe, that this position has been favourable, and perhaps essential, to the development of life on the earth, and that earth is the only inhabited world. Dr. Wallace discusses the results of scientific research in relation to the unity or plurality of worlds, and considers such questions as: Are the stars infinite? our relation to the Milky Way; physical conditions of life; are the stars useful to us? and so on, and in later editions he has added a chapter supporting his theory by arguments from evolution—upon which subject he must, of course, be held a supreme authority. Dr. Wallace's conclusions on this subject are not generally accepted, and they clearly challenge views now widely held as to the possibility of life in other worlds; but the theory of this volume is enthralling in its human interest, and the right of the author to be heard is beyond all question.

The Astronomy of the Bible. By E. W. Maunder. Hodder & Stoughton .. .. .. 5s. net A most interesting book, written with a wise sympathy. The author deals astronomically with the many astronomical allusions in the Bible, but endeavours to see the heavens with the eyes of the patriarchs and prophets, and so understand their attitude towards them.

Myths and Marvels of Astronomy. By R. A. Proctor. (Longmans.) 3s. 6d.

Saturn and Its System. By R. A. Proctor. (Chatto & Windus.) 6s.

Astronomy without a Telescope. By E. W. Maunder. (Thacker.) 5s.

Celestial Objects for Common Telescopes. By J. W. Webb. (Longmans.) 12s. 6d.

Astronomy with an Opera-glass. By Garrett P. Serviss. (Appleton.) 6s.

Handbook of Descriptive Astronomy. By G. F. Chambers. (Clarendon Press.) 3 vols. 32s. net.

The Visible Universe. By J. E. Gore. (Lockwood.) 16s.

Studies in Astronomy. By J. E. Gore. (Chatto.) 6s.

GEOLOGY

See also under Geography.

The Student's Lyell: Principles and Methods of Geology. 645 pp. Illus. John Murray .. 7s. 6d. net An epoch-making work in the history of geological science. Sir Charles Lyell was the pioneer of the theory that the changes still in progress are chiefly such as have produced the former changes of the earth's surface, and in this volume covers the whole ground of geology, as known in his day, in the light of this principle. Besides dealing with the face of the earth, Lyell treats of climate and of astronomical changes in their relation to the earth's features; of aqueous and glacial causes of change; of rivers, tides, and currents; of igneous causes, etc. He also deals with flora and fauna, the antiquity of man, the origin of species, and a host of other interesting and kindred subjects.

Textbook of Geology. By Sir Archibald Geikie. Two vols. Illustrated. Macmillan .. .. 30s.
The best work by any British author, reviewing the whole of geology. Though very learned, it is simple and readable; the author's great interest in scenery always makes his work attractive. The chief divisions of the book are: The cosmical aspects of geology; geognosy, or the inquiry into the materials of the earth's substance; dynamical geology; structural geology; palæontological geology; stratigraphical geology; physiographical geology. There is a good bibliography, and a list of geological maps of all parts of the world.

Geology. By Thomas C. Chamberlin and Rollin D. Salisbury. Three vols. Illustrated. John Murray 21s. net each.
A brilliant American work, in which the authors approach the science by a study of the forces and processes now in operation. Encumbered as little as possible by technicalities and unimportant details, but immense in sweep, and intimate in style. Rather too large a work for a general reader to start on, but very valuable and stimulating to advanced students. There is a shorter course in one volume at 21s. net.

An Introduction to Geology. By J. E. Marr. Illustrated. Cambridge University Press .. 3s. net
An attempt to explain the scope and methods of geology without using technical terms or taxing the reader's memory with excess of detail. Useful to general readers who wish to obtain some idea of the science, and especially instructive to the student who intends to proceed to the reading of more advanced treatises.

Classbook of Geology. By Sir Archibald Geikie. 475 pages. Illustrated. Macmillan .. 5s.
The standard introductory work on the study of the structure of the earth. Clearly and simply written, and suitable for the general reader as well as for the young student.

Outlines of Geology. By James Geikie. 436 pages. Illustrated. Stanford .. .. .. 12s.
An introduction for general readers. The parts which the beginner usually finds difficult are treated in greater detail. Gives a broad view of the scope and bearing of the science, with a table of British strata in which fossils are found, and a glossary.

The Founders of Geology. By Sir Archibald Geikie. 497 pages. Macmillan .. .. .. 10s. net
A history of the development of geological science in the form of a series of life-stories of the pioneers and masters of geology. Combines brilliance of style with solidity of thought.

The Student's Handbook of Stratigraphical Geology. By A. J. Jukes-Browne. Stanford .. 12s. net
Consists chiefly of the description of the great stratified series of rocks that make up the mass of the earth's crust. Gives the history of the earth as revealed in the fossil life of each stratum after the earliest rocks. A first-rate handbook.

Earth Sculpture; or the Origin of Land Forms. By James Geikie. 336 pp. Illus. John Murray.. 6s.
A simple but scientific account, for general readers, of the processes by which the land is carved out and moulded and changed by internal fires and glaciers of the Ice Age. An authoritative study of the origin of scenery.

Building of the British Isles. By A. J. Jukes-Browne. Stanford .. .. .. 12s. net
An admirable picture of how the British Islands have come to be what they now are through æons of change. Most valuable.

Structural and Field Geology. By James Geikie. 452 pages. Illus. Oliver & Boyd.. 12s. 6d. net
For beginners in field geology. Deals with rock-forming minerals, rocks, fossils; and the formation of rock-beds, ore-formation, geological surveying, and the industrial and practical aspects of geological structure are explained in some detail. Chapters on soils and subsoils and surface features.

The Work of Rain and Rivers. By T. G. Bonney. Illustrated. Cambridge University Press. 1s. net
Dr. Bonney has written this short account of the work of rain and rivers in such a way as to apply the principles of this branch of geology to the interpretation of scenery. The book is particularly interesting to readers who have travelled, for the illustrations are all drawn from familiar districts.

River Development. By I. C. Russell. 327 pages. Illustrated. John Murray .. .. 6s. net
An admirable study of rivers, illustrated generally by the rivers of North America. The book deals with the disintegration and decay of rocks, laws governing streams, and river deposits.

Cloud Studies. By Arthur W. Clayden. 184 pages. Illustrated. John Murray .. .. .. 12s.
Intended primarily for students of weather-lore and artists, but interesting to all lovers of Nature. Explains the details of cloud structure, and describes and depicts typical varieties of cloud forms. Aims at introducing a greater exactness of language in description. Has a chapter on cloud photography.

Climatic Control. By L. C. W. Bonacina. 167 pages. Illustrated. Black .. .. 2s.
A simple discussion in textbook form of the general principles of climatology, showing how vegetation and other features of the landscape are controlled by climatic influences, and how such influences modify the life of man and his occupations. One of the objects of the writer is to induce the student to observe the climate on his own account, and form his own theories.

The Face of the Earth. By Edward Suess. Four volumes. Clarendon Press .. .. £4 13s. net
The most complete and definite of all the general surveys of geological facts. It embodies the results of personal research, and a study of the work of the leading geologists of all lands, and it approaches nearer absolute comprehensiveness and authority than any similar work in any language.

The Age of Earth. By Arthur Holmes. 196 pages. Illustrated. Harper .. .. .. 2s. 6d. net
Approaches the subject from various sides, dealing with tidal effects, the saltness and age of the oceans, the work of denudation, and the time required for the formation of sedimentary rocks. Discusses the new factor of radio-active substances, which has upset both mathematicians and geologists.

The Story of the Hills. By Rev. H. N. Hutchinson. 356 pages. Illustrated. Seeley .. .. 5s.
In this book the author sets out to tell, in a popular manner, the story of mountains and how they were made, having in mind the thousands who are now able to visit the mountains of Europe during their holidays, and the ladies who climb Mont Blanc or wander among the Carpathians. For such readers the scientific facts and history of mountains are genially rendered in this excellent work.

The Glaciers of the Alps. By John Tyndall. 270 pages. Dent .. .. 1s. net
Professor Tyndall's vivid descriptions of the Alps and of mountaineering are attractive not only because of their scientific value, but also for their interest in scenery and in climbing.

The Romance of Modern Geology. By E. S. Grew. 308 pages. Illustrated. Seeley .. .. 5s.
An account in simple language of the building of the earth, and of the various processes which have been at work producing its present features, with some account, in an interesting manner, of prehistoric animals. Suitable for children over fourteen, and for older readers who are not specialists.

The Making of the Earth. By J. W. Gregory. 256 pages. With maps. Williams & Norgate. 1s.
The sum of evidence as to the origin of the earth, provided by the latest astronomical, geological, palæontological, zoological, and geographical researches is here brought together. The last chapter is a consideration of the origin of life, which the author defines as the problem of "the formation of a self-generating, reproductive, carbonaceous jelly, of such a nature that it served as the beginning of the whole of the organic evolution that followed."

The World's Foundation. By Agnes Giberne. 315 pages. Illustrated. Seeley .. .. .. 5s.
A popular book on geology, for beginners. Would do for children above fourteen.

History of Geology and Palæontology. By K. von Zittel. 362 pages. Portraits. Walter Scott. 6s.
No science has had a more rapid and changeful growth than geology. That growth to the end of the nineteenth century is here traced by the distinguished Professor of Geology in the University of Munich, with remarkably wide knowledge and a complete acquaintance with the personal story that is interwoven with the development of the science. Dr. von Zittel not only tells how the knowledge is accumulated, but, step by step, names the people who have been its collectors. An invaluable book.

The Earth in Past Ages. By H. G. Seeley. 196 pages. Illustrated. Hodder & Stoughton. 1s.
This useful little book tells the story of the earth in the past in such a manner as to explain its present condition. It explains the nature of the common materials which form rocks, the ways in which they rest on one another, and the means by which they may be distinguished. Fossil remains are explained in a similar manner.

Physiography. By Thomas Henry Huxley. Illustrated. Macmillan .. .. 4s. 6d.
An introduction to the study of Nature, by a masterhand. Deals principally with the forces at work in a great river basin, setting out from the commonest and best-known phenomena, such as clouds and rain, dew and ice, and going on to the study of living matter, the movements of the earth, the sun, and gravitation. A standard scientific exposition, recently revised in the light of the latest researches.

Man and the Glacial Period. By G. Frederick Wright. 385 pages. Illustrated. Kegan Paul. 5s.
The author summarises the position of existing glaciers; discusses glacial motion, and signs of past glaciation; locates the ancient glaciers of both hemispheres, and outlines their drainage systems; points out where the relics of man are found in connection with the glacial period, and debates the cause and date of that period.

The Scenery of Scotland Viewed in Connection with its Physical Geology. By Sir Archibald Geikie. 560 pages. Illustrated. Macmillan .. 10s. net
Begins by describing the general processes by which land is sculptured into changing shapes, and then gives particular examples of the work, of geological forces in the highlands, the southern uplands, and the valleys in the midlands.

Ice-work, Present and Past. By T. G. Bonney. 295 pages. Illustrated. Kegan Paul .. .. 5s.
An interesting book because of its distinct aim and individuality. Professor Bonney here tries to give prominence to all those facts of glacial geology on which all inferences must be founded, and he selects for description such phenomena as he has examined personally, assuming in all controversial matters, he claims, the attitude of a judge rather than of an advocate. The result is a fine collection of materials for forming a judgment as to the part played by ice in the story of the world.

The Forms of Water in Clouds and Rivers, Ice and Glaciers. By John Tyndall. Kegan Paul. 5s.
A brilliant and well-known work. Sets out from the waves of heat that produce the vapour of the atmosphere; deals with tropical rains; the condensation by mountains; the architecture of snow and ice, and the formation and motion of glaciers.

The Scenery of England, and the Causes to which it is Due. By Lord Avebury. Macmillan .. 6s.
Attributes the configuration of England, and consequently the scenery, mainly to sub-aerial action. A work on the principles of geology, written in a fresh and vivid manner. Deals with the Great Ice Age, the sculpture of the coast, the origin of the mountains and lakes, and the history of English rivers, fens, downs, and commons.

The Scientific Study of Scenery. By John E. Marr. 372 pages. Illustrated. Methuen .. .. 6s.
This book is intended as an introduction to the scientific study of the existing features of earth, sea, and sky which are visible to the eye; it deals chiefly with the attribute of form and its causes, but also with colour, movement, and character of surface.

Landscape in History, and Other Essays. By Sir Archibald Geikie. Macmillan. .. 8s. 6d. net
Half of the essays deal with scenery in its relation to geological events, and in its influence on human progress; the work brings home to the mind in a vivid way the value of geology.

The Scenery of Switzerland. By Lord Avebury. 473 pages. Illustrated. Maps. Macmillan. 6s.
A brilliant little book on the geological processes which have been at work in producing the Swiss scenery. Lord Avebury, who travelled in Switzerland in the company of Tyndall and Huxley, and later spent many holidays in the Alps, had a keen eye for natural grandeur and beauty, and succeeded in showing how the physical features of the country are produced and how they are changing.

The Origin of Earthquakes. By C. Davison. 141 pages. Illus. Cambridge Univ. Press. 1s. net
This book considers the origin of different classes of earthquakes, and describes fully one or two examples of each class. The growth of "faults" is discussed; then the origin of simple earthquakes; twin earthquakes; complex earthquakes; fore-shocks; after-shocks; and, finally, sympathetic earthquakes.

Earthquakes and other Earth Movements. By John Milne. 361 pages. Illustrated. Kegan Paul. 5s.
Professor Milne was the founder of the science of earthquakes, and the inventor of the instrument for recording earth movements. His work is written in a clear and authoritative manner, and is not too difficult for the general reader.

The Geology of Building Stones. By J. Allen Howe. 455 pages. Illustrated. Arnold .. 7s. 6d. net
A practical book of reference for architects and students of geology. Gives a list of the principal granite, sandstone, limestone, and slate quarries, and deals generally with our building stone resources.

A Study of Recent Earthquakes. By Charles Davison. Illustrated. Walter Scott .. 6s. An interesting collection of accounts of earthquakes in all parts of the world, covering very wide ground, and bringing together facts not previously collected in one volume. The final chapter gives a summary of the results of earthquake study.

The Physics of Earthquake Phenomena. By C. G. Knott. Illustrated. Clarendon Press. 14s. net The author, who has been Professor of Physics in the Imperial University of Japan, has had special facilities for studying earthquakes, and adds personal investigation to a very complete knowledge of the literature of the subject. A thoughtful book for advanced students.

Volcanoes and Earthquakes. By E. J. Houston. 325 pages. Illustrated. Chambers .. 2s. 6d. An account of some of the most memorable volcanic eruptions and earthquake shocks, from the destruction of Pompeii to the destruction of San Francisco. Descriptions are given of the best-known groups of volcanoes. There are chapters, too, on submarine volcanoes and the extinct volcanoes of the moon. A popular treatment of the subject.

Volcanoes Past and Present. By Edward Hull. 270 pages. Illustrated. Walter Scott .. 3s. 6d. A popular account of the volcanic and seismic phenomena of the globe as manifested in certain notable eruptions. The book endeavours to find an answer to two important questions: Are we living in an epoch of extraordinary volcanic energy? and What is the ultimate cause of volcanic action?

Volcanoes. By John W. Judd. 381 pages. Illustrated. Kegan Paul .. .. .. 5s. A popular exposition of the present condition of knowledge respecting volcanoes, with an account of investigations that in recent times have thrown fresh light on the whole problem. These investigations include the character of lavas, as revealed by microscopic examination; the nature and movements of liquids enclosed in the crystals of igneous rocks, and the relation of minerals in volcanic products to those found in meteorites.

Volcanoes: their Structure and Significance. By T. G. Bonney. 378 pages. Illus. John Murray. 6s. A simply written but authoritative book on the subject. Describes the activities of a living volcano from birth to death. Deals with the geological history of volcanoes in the past and present. A general survey of the problems of volcanic action.

Coal and What We Get From It. By Raphael Meldola. Illustrated. S.P.C.K. .. .. .. 2s. 6d. To the reader who is unaware what a variety of useful products are obtained from coal by modern industry, this book, by the Professor of Chemistry at the Finsbury Technical College, will come as an astonishing revelation. Specially interesting are the processes by which brilliant dyes are obtained.

The Geology of Coal and Coal-Mining. By Walcot Gibson. Illus. 341 pages. Arnold. 7s. 6d. net Deals in an elementary manner with the strictly scientific side of the subject, and explains all the geological terms used by miners. Describes formation and origin of coal, the art of prospecting and boring, and surveys the coalfields of Britain at length, and the coalfields of the rest of the world in a more concise manner.

Our Common British Fossils. By J. E. Taylor. 331 pages. Illustrated. Routledge .. 3s. 6d. A handy book for young students, dealing only with invertebrate fossil animals—the most numerous class of all.

Textbook of Petrology. By F. H. Hatch and R. H. Rastall. 2 vols. Allen & Unwin. 7s. 6d. net each. A very valuable but highly scientific description of the sediments and their metamorphic derivatives. A useful contribution to a branch of geology which has perhaps been rather neglected. There is a most useful appendix, in which Mr. T. Crook summarises the modern methods of separating and determining the minerals occurring in clays, sands, and soils.

The Natural History of Clay. By A. B. Searle. 176 pages. Illus. Cambridge University Press. 1s. net Though clay is so useful, and long has been, we know little of its properties when in a pure state. This volume outlines what is known, and indicates unsolved problems. For instance, many clays owe their chief value to plasticity, but plasticity is of an elusive nature, and almost defies measurement.

The Old Red Sandstone. By Hugh Miller. 363 pages. Dent .. .. 1s. net The story of how the author found fossils in the lower old red sandstone, and fixed in the geological scale the place to which the larger beds of remains found in the system belong. Some of the work of Miller has been superseded by later experience, but his book will always live, because of the imaginative power he used in picturing the vanished past.

Crystalline Structure and Chemical Constitution. By A. E. H. Tutton. 204 pages. Illustrated. Macmillan .. .. 5s. net Presenting, in a concise manner, the author's original contributions to the problem of the relation between the form, structure, and physical properties of crystals and the chemical composition of the substances composing them.

Rocks and their Origins. By G. A. J. Cole. 175 pages. Illus. Cambridge University Press. 1s. net An introduction to geology for the general reader, discussing simply and clearly, first, rocks in general, and then, in separate chapters, limestones, sandstones, clays and slates, igneous rocks, and metamorphic rocks. There is a useful bibliographical reference table.

Petrology for Students: Study of Rocks under the Microscope. By Alfred Harker. 336 pages. Illustrated. Cambridge University Press .. 7s. 6d. A guide to the study of rocks in thin slices, that needs to be supplemented throughout by demonstrations on actual specimens. Designed for English-speaking students, and dealing with British, American, and Colonial rocks. A useful book on a comparatively new study.

The Natural History of Igneous Rocks. By Alfred Harker. 384 pages. Illus. Methuen. 12s. 6d. net This book contains the substance of a course of lectures by the author, who is Professor of Petrology in the University of Cambridge. It is a work for serious students, but eminently readable. Igneous action and igneous rocks are first considered from a geological standpoint, and brought into their proper relation with other parts of historical geology. The middle part of the book deals with the crystallisation of igneous rock-magmas. Finally, the genesis of igneous rocks is considered, and in the last chapter a natural classification is attempted.

Extinct Animals. By Sir E. Ray Lankester. 354 pages. Illustrated. Constable .. .. 3s. 6d. A vivid and brilliant attempt to describe the vanished monsters and strange creatures that once inhabited our earth. Written by a leading man of science of the day, who combines a talent for literature with a remarkable range of knowledge, this is one of the best popular books on the subject.

Natural History of Coal. By E. A. N. Arber. 156 pages. Illus. Cambridge University Press. 1s. net
There was a time when scientific men regarded the natural history of coal as a simple matter. Not so now. It is crowded with unsolved problems. This Mr. Arber realises. He sees that all types of coal were not derived from the same type of "mother substance." So he does not dogmatise, but states theories fairly, while considering the conditions under which different coals have accumulated.

The Geology of Water-Supply. By Horace B. Woodward. 339 pages. Illustrated. Arnold. 7s. 6d.
Deals with the knowledge of the geological structure of the ground and the character of rock-formation necessary in obtaining an adequate supply of potable water. Study of water-bearing strata, springs, underground sources, with a chapter on prospecting for water. Written with special reference to Great Britain, but touches other water supplies.

Extinct Monsters and Creatures of Other Days. By Rev. H. Hutchinson. Chapman & Hall. 10s. 6d.
This book, with a companion volume on "Extinct Monsters," by the same author and publishers, forms an admirable survey of the old-time creatures that have passed away from the earth. The whole of the knowledge in these volumes is practically the outcome of the research of the last two generations, and the story of these "lost creations" is in itself fascinating reading, while throwing light also on the early history of living things.

ARCHAEOLOGY

See also under History, Ancient and Social Evolution.

A Bibliographical List of Roman and British Architectural Remains. By Arthur H. Lyell. Cambridge University Press .. .. 7s. 6d. net
In this list—which is only a list and not a book of comment—the compiler mentions all antiquarian excavations of the Romano-British period, and the books or journals in which the results of the excavations are recorded.

A Century of Archæological Discoveries. By Prof. Michaelis. John Murray .. .. 12s. net
It is almost impossible to keep a review of archæological research up to date, for the work is carried on constantly over an enormous field. This translation from the German, which has the good word of Professor Percy Gardner of Oxford, brings the story along as far as the Cretan excavations by Evans. The book is a very useful survey up to the beginning of the twentieth century.

The British Museum: Its History and Treasures. By Henry C. Shelley. Pitman .. 12s. 6d. net
The author's summary of his book is "a view of the origins of the British Museum, its early benefactors and principal officers, and a survey of the priceless objects it preserves." The literary work is slight, sketchy, and agreeable, with much quotation.

Archæology and False Antiquities. By Dr. R. Munro. Methuen .. .. .. 7s. 6d. net
In this volume Dr. Munro exposes what he calls "the backwash of archæological imposture." Everywhere the value placed on remains of the distant past has led to attempts at manufacturing relics. Dr. Munro has the kind of mind that distrusts whenever it is asked to jump to a conviction. He proves the great need for scientific reserve.

Brasses of England. By H. W. Macklin. Methuen. 7s. 6d. net
A general survey of the monumental brasses still existing in England. The industry of the writer is on a level with his expertness and enthusiasm.

Parish Life in Mediæval England. By Cardinal Gasquet. Methuen .. .. .. 7s. 6d. net
A fascinating book by a writer who has both great knowledge and literary charm. The topics are the parish, its church, its clergy, the officials, parochial finance, the church services, the festivals, the sacraments, the pulpit. Parish amusements, guilds, and fraternities. The illustrations are many and good.

Parish Registers of England. By J. C. Cox. Methuen .. .. 7s. 6d. net
Dr. Cox has spent half a century in studying parish registers, and the results come with his book. He shows the action of the law on them; their relations to marriages, baptisms, burials, accidents, epidemics, and notable historical and scientific occurrences. A book of solid value and salutary influence.

Romano-British Buildings and Earthworks. By John Ward. Methuen .. .. 7s. 6d. net
This book not only describes the towns, forts, houses, and structural remains of the period it deals with, but attempts to interpret them. It discovers, discusses, and illustrates an astonishing amount of Roman work in our country. The writer proceeds with an impressive confidence.

Mallet: Northern Antiquities. Bell .. 3s. 6d.
Bishop Percy's translation from the French of M. Mallet's "Northern Antiquities" is of lasting interest, partly because it gives much information respecting the early people of Denmark, Norway, Greenland, and Iceland, and partly because it enables us to see the kind of literature which arrested the attention of Scott and other writers who carried on the best traditions of romance.

Ruins of Desert Cathay. By Sir Aurel Stein. 2 vols. Illustrated. Macmillan .. .. 42s. net.
This substantial book is a record of personal experiences during the exploration of the westernmost parts of China and parts of Central Asia. The writer, who is superintendent of the Indian Archæological Survey, is equally experienced as a traveller, an archæologist, and a writer.

Earthwork of England. By A. Hadrian Allcroft. Illustrated. Macmillan .. .. 18s. net
This valuable modest book makes no pretence to cover the whole of the ancient earthworks of England. The writer only describes what he has examined personally; but he uses his observation so as to suggest the systematisation of such works, and the working out of a generally applicable history for them. The book is abundantly illustrated with plans of ancient "works." It is the most comprehensive presentation of the subject in a popular form.

Byways in British Archæology. By Walter Johnson. Illustrated. Cambridge University Press. 10s. 6d.
The writer of this attractive book holds that there is such a thing as a popular or "folk" memory, and that it keeps alive many semi-historical survivals. Examples are here collected with special reference to the village church and churchyard. The building of churches on pagan sites is investigated, and the secular uses of churches in earlier times are illustrated. These and similar questions are discussed with acumen and care. The book has many well-chosen illustrations.

Brasses. By J. S. M. Ward. Cambridge University Press .. .. 1s. net
Aims at giving the general reader a fair idea of the classes into which monumental brasses may most readily be grouped, and enable him to distinguish the salient points of each.

The Care of Ancient Monuments. By G. Baldwin Brown. Cambridge University Press. 7s. 6d. net
The Professor of Fine Arts in the University of Edinburgh here gives an account of the legislative and other measures adopted in European countries for protecting ancient monuments and objects and scenes of natural beauty, and for preserving the aspect of historical cities. He also seeks to establish a fitting æsthetic standard with architecture of towns. The question of "restoration" is also considered. An excellent book.

The Green Roads of England. By R. Hippisley Cox. Methuen .. .. 10s. 6d. net
The "green roads of England" are the travels that follow the watersheds from certain hill centres, and were defended, at frequent intervals, by camps in the Stone Age. These roads are traced by the writer with much sympathetic skill. Beginning with Avebury, the ridgeway from Salisbury Plain to the Mendips is followed. Then Dorsetshire, Hampshire, and Wiltshire are visited, the watersheds of the upper Thames, and the Eastern watershed. The book is of enthralling interest to the antiquarian. The illustrations are adequate.

The Castles and Walled Towns of England. By Alfred Harvey. Methuen .... 7s. 6d. net
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DRAWING

ANTIQUARIAN—A drawing-paper 52 in. long by 31 in. wide.
Arrow Head—Crows' feet [*q.v.*].
Atlas—A drawing-paper 34 in. long by 26 in. wide.

BATTER—A set square having its angle other than 30°, 45°, or 60°.
Beam Compasses—Trammels [*q.v.*].
Bisecting Compasses—Wholes and halves [*q.v.*].
Black Line Process—Ferro-gallic process [*q.v.*].
Blue Print—Ferro-prussiate process.
Bordering Pen—Special drawing-pen for borders.
Bow Compass—Medium-size compasses.

CABINET NEST—A nest of superimposed palettes fitting into each other.
Calculating Rule—Slide rule [*q.v.*].
Cartridge Paper—A strong, cheap drawing-paper.
Centre Line—A line drawn through the centre of a piece of work; used as a basis for measurements.
Centrolinead—An instrument used for drawing lines to inaccessible vanishing-points.
Chinese Ink or Indian Ink—Used for inking in drawings and tracings.
Chinese White—Used for marking white lines on blue prints, etc.
Chords, Scale of—A means by which an angle can be laid off by taking compass measurements from the scale.
Columbier—A drawing-paper 34 in. long by 23 in. wide.
Compasses—Instruments used for describing circles.
Compass Scale—A short metallic scale let into a T-square or scale, for taking measurements by compass.
Continuous Paper—Paper supplied in roll instead of cut standard sheets.
Copier—An electric copier [*q.v.*].
Copying Frame—A frame in which tracings are copied or photographed.
Crows' Feet—Angular lines < > used to indicate the limit of a dimension line.
Cursor—The metallic slider upon a slide rule.
Curves—Railway curves [*q.v.*], French curves [*q.v.*].

DATUM LINE—The horizontal base line from which heights and depths are measured.
Demy—A drawing-paper 20 in. long by 15 in. wide.
Detail Drawing—A drawing which fully delineates one or more portions of a machine.
Dimension Line—A line which indicates the extent of a dimension.
Dividers—A form of compass with plain points, used for dividing a line into a number of equal parts.
Dotting Pen—A drawing-pen with a device to produce a dotted line automatically.
Double Elephant—A drawing-paper 40 in. long by 27 in. wide.

ELECTRIC COPIER—Machine for producing phototypes by electric light.
Elevation—A drawing of an object projected on to a vertical plane by means of projectors drawn perpendicular to the vertical plane from each point of the object.
Emperor—A drawing-paper 72 in. long by 48 in. wide.
Engine Divided—The marking of a scale or rule by a machine or engine.

FERRO-GALLIC PROCESS—A phototype process producing black lines on white ground.
Ferro-prussiate Process—A phototype process producing white lines on blue ground.
Flexible Curves—Strips of steel or other suitable material with attachments at intervals for deflecting and holding to any desired curve.
French Curves—Fancy curves of varying radii.

GENERAL DRAWING—A drawing which shows a machine entire.
Graphic Method—A method of determining a factor or a dimension by drawing instead of by calculation.

HAIR DIVIDER—A fine screw adjustment fitted to the leg of dividers to obtain exact measurements.
Horn Centre—A small piece of horn upon which to pivot a compass leg in order to avoid piercing the paper.

IMPERIAL—A drawing-paper 30 in. long by 22 in. wide.
Irregular Curves—French curves [*q.v.*].

KNIFE KEY—A steel implement which combines screwdriver, penknife, file, etc., for adjusting instruments, sharpening pencils, etc.

LENGTHENING BAR—An extension bar used with large compasses to increase their radius.

MEDIUM—A drawing-paper 22 in. long by 17 in. wide.
Metre Scales—Used for making drawings to metrical dimensions.
Mounted Paper—A paper mounted upon linen to give it strength and durability.

NAPIER COMPASSES—A folding compass for the pocket.
Needle Point—A compass point consisting of an ordinary needle held in place by a screw, and consequently easily renewable.

ODONTOGRAPH—A combination scale used to facilitate the marking out of wheel teeth.
Oxgall—Used occasionally with inks and colours to make them work freely.

PALETTES—Ware receptacles for mixing colours.
Paper—"Hot-pressed" has a very smooth surface; "Not" has a medium surface; and "Rough" has a coarse surface.
Paper Scales—Scales engraved upon stout paper or Bristol board, convenient for measuring curves
Parallel Rule—A straightedge or rule fitted with parallel joints or milled rollers to facilitate the drawing of parallel lines.
Photoprint or Phototype—A copy of a tracing produced by the action of light upon a sensitised paper.
Pillar Compasses—Folding compasses for the pocket, forming a set of instruments.
Plan—A drawing of an object projected on to a *horizontal* plane by means of projectors drawn perpendicular to the horizontal plane from each point of the object.
Planimeter—An instrument used for computing areas.
Pricker—An implement with a needle point; used for pricking through centres and curved outlines where the paper is too opaque for tracing.
Printing Frame—A glazed frame used for phototype printing.
Proportional Compasses—Double-ended dividers with adjustable fulcrum, used for reproducing dimensions at any predetermined proportion.
Protractor—A scale, usually circular, which has the degrees of a circle marked thereon.

RAILWAY CURVES—Regular curves usually made in sets, and varying from 1½ in. to 240 in. radius.
Retree Paper—Slightly defective sheets of paper.
Royal—A drawing-paper 24 in. long and 19 in. wide.

SECTION—A view of an object cut through in order to show its construction and interior.
Sectional Colours—Various colours recognised as representing various metals and materials.
Sectional Elevation and Sectional Plan—See page 3412.
Sectional Paper—Paper ruled in squares to scale either English or metrical measures; useful for sketching to scale, plotting of curves, etc.
Sector—An instrument constructed like a hinged ruler, and having various lines and divisions on it, by which other lines can be divided into any number of equal parts. Also used for constructing regular polygons.
Sensitised Paper—A chemically prepared paper for photoprinting.
Set Square—A sheet of vulcanite, pearwood, etc., cut to form a right angle with two of its edges, the third edge being 30°, 45°, or 60° angle.
Slide Rule—A rule with a sliding portion, engraved upon a logarithmic basis, to facilitate calculations.
Slope—A batter [*q.v.*].
Spring Bows—A small pair of compasses which maintain their full radius by reason of their spring formation; the radius is reduced by drawing the legs together by a screw.
Standards—Regular proportions of machine details which are tabulated for reference.
Stencils—Used for numbering drawings, corners for borders, etc.
Straightedge—A flat strip of wood with an accurately finished edge for drawing straight lines.
Stress Diagram—A diagram drawn so as to represent stresses graphically.
Sun Copy—A phototype [*q.v.*] printed by daylight.
Super Royal—A drawing-paper 27 in. long by 19 in. wide.

TAPE—A continuous band of linen or steel coiled in a leather case, and engraved in feet and inches, etc., usually either 33 yds. or 66 yds. long.
Template—A piece of paper or cardboard cut to the exact outline of an object, to facilitate manufacture.
Tracing—A reproduction of a drawing on a transparent paper or linen.
Tracing Frame—A frame holding a sheet of glass, used to trace old drawings and prints which are best seen through the tracing paper when the light strikes from beneath.
Tracing Linen or Cloth—A prepared transparent linen for tracings.
Tracing Paper—A prepared transparent paper for tracing.
Trammels—A straight bar upon which slide movable heads carrying pen or pencil points, for striking large radii.
Triangular Scale—A scale of triangular section having six working edges and a great number of scales.
T-square—A piece of mahogany or pear-wood with a headpiece in the form of a **T**, used for producing parallel lines, and as a base for set-squares.

UNIVERSAL SCALE—A scale upon which all ordinary scales are marked in parallel rows.

VERNIER—A short scale made to slide along a graduated instrument, for measuring very small intervals.

WHEEL PEN—A drawing-pen with wheels for dotted work.
Wholes and Halves—Compasses fixed at the proportion of one to two.

PHYSIOLOGY

SEE ALSO BIOLOGY AND BACTERIOLOGY

ACETABULUM — The socket in hip joint into which thigh-bone head fits.
Afferent nerve—A nerve which carries an impulse to the brain.
Afferent vessel — Carries blood to lungs or other purifying organ.
Alimentary—Pertaining to food.
Ampulla—Part of the internal ear in vertebrates.
Aorta—The main artery of the body.
Appendix—A blind tube extending from the cæcum.
Arterial—Pertaining to an artery. Pure blood.
Artery—A vessel carrying blood *from* the heart.
Articulation—A joint.
Assimilation—The process of converting digested food into body tissue.
Auricle—A cavity in the heart.

BICEPS—The muscle which bends the fore-arm.
Bicuspid—The first two grinding teeth in each jaw.
Bile—The secretion of the liver.
Bile-duct—Tube leading from liver to intestine which carries the bile.

CÆCUM—A blind tube in intestines.
Calcaneum—The heel-bone.
Canine — The eye-teeth, outside the incisors.
Capillaries—Microscopic blood-vessels having very thin walls.
Cardiac—Pertaining to heart.
Carotid—The main artery carrying blood to the head.
Carpal—Pertaining to the wrist.
Carpus—The bones of the wrist.
Cartilage—Gristle; the covering of the ends of many bones.
Caval veins—The large veins which carry impure blood to the heart.
Centrum—The body of a vertebra.
Cephalic—Pertaining to the head.
Circulatory organs—The structures which convey blood and lymph.
Coagulation—The process of clotting in blood.
Cochlea—A bony part of internal ear.
Columnar epithelium — Epithelium made of elongated cells placed at right angles to the surface.
Condyle — A bony projection which helps to form a joint.
Connective tissue—That which binds or connects tissues together.
Contractile — Having contracting power.
Cornea—The membrane in fore part of eye through which light passes.
Corpuscles—Microscopic cells in blood or lymph.
Cortex—The outer layer of brain.
Costal—Pertaining to the ribs.
Cranial nerves—Nerves which arise from the brain.
Cranium—The brain-case or skull.

DENTINE—The hard part of teeth.
Dermis—The inner layer of skin.
Diaphragm — The muscle separating the chest from the belly.
Dorsal—Pertaining to the back.
Duct—A tube, generally carrying the secretion of a gland.
EFFERENT NERVES—Nerves transmitting impulses from the brain.
Efferent vessels—Vessels which carry pure blood from the lungs.
Embryology—Science of development.
Epidermis—The outer protective layer of skin.
Epiglottis—An elastic structure which prevents food entering air-passages.
Epithelium—Cells which cover surfaces on or in the body.
Excretion—The processes by which waste matters are expelled.
Extensor—A muscle which straightens or extends a limb.

FEMORAL—Pertaining to thigh.
Femur—The thigh bone.
Fibula—The smaller bone on the outer side of the lower leg.
Flexor—A limb-bending muscle.
Foramen—A hole in a bone through which a vessel or nerve passes.

GALL—Bile.
Gall-bladder—The bag in which the bile is stored.
Ganglion—Collection of nerve-cells.
Gastric—Relating to the stomach.
Gastric juice—The digestive fluid of the stomach.
Glenoid cavity—Socket into which head of upper arm bone fits.
Glottis—The opening into windpipe.
Grey matter—The cellular part of the nervous system.

HÆMOGLOBIN—The colouring matter of blood, which carries oxygen.
Hepatic—Pertaining to the liver.
Humerus—The upper arm bone.

INSERTION—The end of a muscle attached to a movable part.
Intercostal—Between the ribs.
Iris—The coloured part of eye.

LACTEALS—Lymphatic vessels of the intestine.
Larynx—The voice-box.
Ligament—A strong fibrous band connecting two bones.
Lymph—A clear colourless fluid containing corpuscles.
Lymphatic gland—A swelling on a lymphatic vessel.

MAXILLA—A bone of the jaw.
Membranous labyrinth—Part of internal ear.
Mesentery—A membrane which holds the intestines in position.
Metabolism — The chemical changes which take place in the body.
Metacarpus—The bones of the palm.
Metatarsus—The bones of the instep.
Mitral—Valves on the left side of the heart, between auricle and ventricle.
Molar—A permanent cheek tooth.
Mucous membrane—A soft membrane lining a tube.

NERVE-CELL—The essential part of a nerve unit.
Nerve-fibre — The thread extending from a nerve cell.
Neural—Pertaining to the nerves.
Neuron—A nerve cell and its prolongations.
Nuchal—Pertaining to nape of neck.

ŒSOPHAGUS—The gullet.
Oral—Pertaining to the mouth.
Orbit—Cavity containing eyeball.
Origin—The end of a muscle attached to a fixed part.
Osmosis—The process by which fluids or substances pass through a membrane.
Ossicle—A little bone.
Ovary—The female sexual organ containing eggs.
Ovum—An egg cell.

PANCREAS—The sweet-bread, a gland in the abdomen.
Papilla—A little projection.
Parotid—A gland producing saliva.
Patella—The knee-cap.
Pelvis—The bones to which the hind or lower limbs are joined.
Pepsin—A digestive ferment in gastric juice.
Peptone—A soluble substance produced in digestion.
Pericardium—The membrane in which the heart lies.
Peristaltic—The movements of the intestine.
Phagocyte—A colourless corpuscle.
Phalanges—The finger and toe bones.
Pharynx—Cavity at back of mouth.
Physiology—Science of function.
Portal—Pertaining to the vessels which carry blood to the liver.
Pulmonary—Pertaining to lungs.
Pyloric—The end of the stomach nearest the intestine.

RADIUS—The bone of the forearm on the side of the thumb.
Retina—The internal coat of eye.
Rouleaux—Little rolls or chains of blood corpuscles.

SALIVARY—Glands producing saliva.
Scapula—The shoulder-blade.
Sclerotic—The external hard coat of the eye.
Sebaceous gland—A gland producing an oily secretion.
Segmentation—The early divisions of a germ cell.
Semilunar—The name of three valves at the beginning of the pulmonary artery and the aorta.
Sensation—A state of consciousness.
Serum—The colourless fluid element of the blood.
Spinal cord—The mass of nerve tissue with the spinal column.
Spleen—A large gland in the abdomen.
Stationary air—Air which remains still in the lungs in breathing.
Sternum—The breast-bone.
Sympathetic nervous system—Part of the nervous system regulating blood supply and other functions.
Synovia—The fluid which lubricates the joints.
Synovial—That which secretes synovia, *e.g.* the synovial membranes.

TARSUS—The bones of the ankle.
Tendon—The strong fibrous band which attaches a muscle to a bone.
Thoracic duct—Tube which receives lymph and opens into the great neck veins.
Thorax—The chest.
Thymus—A ductless gland near heart.
Thyroid—A ductless gland in neck.
Tibia—The shin-bone.
Tidal air—Air taken in at an ordinary breath.
Trachea—The windpipe.
Tricuspid—Valves on right side of heart, between auricle and ventricle.
Tympanum—The drum of the ear.

ULNA—The bone of the forearm on the little-finger side.
Ureter—The tube which carries urine from the kidney.

VALVE—A flap in a vessel or tube preventing backward flow of fluid.
Vein—A vessel carrying blood towards the heart.
Venous—Pertaining to a vein. Impure blood.
Ventricle—The thick-walled chambers of the heart which by contracting force blood into the arteries.
Vertebra—A bone of the backbone.
Viscera—The internal organs.
Vocal chords—Two thin folds of elastic tissue in the larynx.
WHITE MATTER—The nerve fibres of the nervous system.

ACIDIMETRY—The determination of the amount of acid in a substance.

Albumens or **Albumins**—A group of proteins soluble in water. Egg albumin (white of egg) is an example.

Albuminoids—Organic carbon compounds containing hydrogen, oxygen, nitrogen, and sometimes sulphur, and of very complex nature. They are essential both to animal and plant life.

Albuminoid Ammonia (in water)—Ammonia obtained by distillation with alkaline permanganate by Wanklyn's method.

Alcohol—Generally understood to mean ethyl alcohol, C_2H_5OH, a constituent of alcoholic beverages, and obtained by the fermentation of sugar. The term is also applied to substances of similar composition.

Aldehydes—Substances obtained by the careful oxidation of alcohol.

Alizarine—One of the colouring matters of madder (*Rubia tinctoria*), the other being purpurin. Also prepared artificially from coal-tar.

Alkalimetry—The determination of the amount of alkali in a substance.

Alkaloids—Bases obtained from plants and possessing highly poisonous or medical properties.

Alloy—An intimate mixture (possibly containing compounds) of metals with one another.

Alum—A double sulphate of alumina and another metal, crystallising in the regular system with 24 molecules of water. The name is often applied in commerce to sulphate of alumina alone.

Amalgam—An alloy of mercury with another metal or metals.

Amorphous — Without crystalline structure.

Aniline—A colourless oil obtained indirectly from coal-tar and belonging to the class of primary amines.

Aniline Dyes—Dyes obtained from aniline. The term is often incorrectly applied to all coal-tar dyes.

Animal Charcoal or **Bone Black**—A substance obtained by carbonising bones.

Animal Oil or **Bone Oil** — An oil obtained by distilling bones.

Anthracene—A white crystalline solid from coal-tar and the mother substance of the alizarine dyes.

Antichlor—Sulphites and other substances added to destroy any residues of chloride of lime left in a fibrous material after bleaching.

Antifebrin—Acetanilide; an antipyretic.

Antipyretic—Medicinal substance to allay fever.

Antipyrine—Phenyl-dimethyl pyrazolone; an antipyretic.

Apatite—A mineral phosphate and fluoride of calcium.

Aqua-fortis—Nitric acid.

Aqua-regia—A mixture of one part nitric acid and four parts hydrochloric acid.

Argol—Crude bitartrate of potassium.

Asbestos—A fibrous mineral substance used in making fireproof articles.

Ash—Calx or mineral matter left on burning organic substances.

Asphalt—A natural mineral bituminous substance.

Aspirator—A machine to draw a current of air or other gas through an apparatus.

Assay—The determination of the quantity of a constituent contained in a substance.

-Ate—The termination of the names applied to salts of acids containing oxygen.

Autoclave—A digester or closed vessel in which liquids can be heated above their boiling points.

Azo—The group $N=N$ characteristic of a large number of colouring matters derived from coal tar.

BALSAMS—The exudations of plants consisting of resins, volatile oils, aromatic acids, and other substances.

Base—A metallic oxide or organic radical having the power of combining with an acid.

Basic—Having the properties of a base.

Bauxite—A naturally occurring hydrated oxide of alumina.

Beaker—A tumbler-shaped vessel of thin glass.

Benzaldehyde—Oil of bitter almonds: C_6H_5CHO.

Benzene—A liquid volatile hydrocarbon (formula C_6H_6) contained in coal-tar.

Bittern—The mother liquid that remains after common salt has crystallised out from sea-water.

Blacklead—Plumbago or graphite; a form of carbon.

Bleach or **Bleaching Powder**—Chloride of lime or calcium hypochlorite.

Blue-stone—Sulphate of copper.

Boiled Oil—Linseed oil which has been heated in air with litharge, manganese borate, or other substances, so that it has become thick and viscous.

Boiling-point—The temperature at which a liquid boils, the pressure being that of a normal atmosphere unless otherwise stated.

British Gum—*Dextrin.*

Bunsen Burner—Gas-burner having holes at the bottom for the admission of air.

Burette—A graduated glass tube provided with a stop-cock at the bottom for measuring fluids.

CALCINATION—The operation of ignition or heating till nothing but a mineral residue or calx remains.

Calc-spar—Native crystalline calcium carbonate.

Calibration—The process of ascertaining whether a vessel or other measuring apparatus holds or delivers the exact volume marked upon it.

Caliche—Impure native nitrate of soda or Chili saltpetre.

Calomel—Mercurous chloride.

Calorie—Metrical unit of heat, being the amount of heat required to raise one gramme of water 1° C.

Calorimeter—Apparatus for measuring heat, usually the amount of heat developed by substances when burnt.

Caramel—Brown colouring matter obtained by heating sugar or glucose.

Carbide—A compound of a metal with carbon—as calcium carbide.

Carbohydrate—A compound of carbon, hydrogen, and oxygen, the relative proportions of the two latter elements being the same as in water—as sugar.

Carbolic Acid—Phenol: C_6H_5OH. A constituent of coal-tar.

Carbonyl—The group CO—that is, a group composed of a carbon and oxygen atom in combination.

Carborundum—An extremely hard substance containing carbon and silicon.

Catalysis—The effect by which two substances are enabled to react in virtue of the presence of a small quantity of a third substance termed a *catalytic agent.*

Contact Action—A synonym for catalytic action. See *catalysis.*

Centinormal — One-hundredth of normal strength.

Chamber Acid—The crude sulphuric acid which collects on floors of the lead chambers; of a strength not usually exceeding 70 per cent. of pure acid.

Chili Saltpetre—Sodium nitrate.

China Clay—Kaolin, the purest variety of clay.

Chloride of Lime—Bleaching powder or calcium hypochlorite.

Cinnabar—Native sulphide of mercury or vermilion.

Cochineal—The body of a female insect which produces red dye-stuff.

Collodion—A solution of soluble nitrocellulose in a mixture of alcohol and ether.

Colloid—A substance in the amorphous non-crystalline state — as India-rubber, glue, cellulose.

Colophony—See *rosin.*

Commercial Chemicals — Such as have not been specially purified.

Compound—A substance composed of two or more elements in combination with one another.

Condenser—Apparatus for condensing a vapour to a liquid, consisting commonly of a tube surrounded by a jacket of cold water,

Constitution—The mode in which elements are combined with one another in a compound.

Corundum—Native alumina or oxide of aluminium of the same composition as sapphire and ruby.

Creosote—Substance obtained by distilling wood or coal-tar.

Crucible—Cup-shaped vessel of fire-resisting material in which substances can be strongly heated.

Crude Product—Unpurified material obtained in chemical manufacture or laboratory work.

Cryolite—A native fluoride of aluminium and sodium.

Crystals—Characteristic geometrical shapes bounded by plane surfaces in which most solid substances occur, especially when separated from solution or on solidification.

Crystalline Systems—The six classes into which all known crystalline shapes are grouped.

DEAD OILS—The name applied to that portion of the coal-tar distillate which sinks in water.

Decantation—The process of pouring off the clear liquid after the solid matter has settled to the bottom.

Decinormal—One-tenth of normal strength.

Deliquescence—The absorption by a substance of moisture from the air, at times in sufficient quantities to cause it to liquefy.

Density—The mass of a unit volume of a substance. See also *specific gravity.*

Dephlegmator—A type of reverse condenser chiefly used in distilleries for freeing alcohol from water.

Desiccation—The process of drying.

Desiccator—As used in analytical work, a glass vessel with ground closely-fitting lid containing a hygroscopic substance such as calcium chloride, strong sulphuric acid or phosphorus pentoxide, so that any body placed inside rapidly loses its moisture and dries.

Dextrin—A gummy substance obtained from starch by the action of diastase.

Dextro-rotatory—Rotating the plane of polarisation of light to the right.

Dextrose—Grape sugar, a six-carbon sugar obtained from starch.

Diamines—Diamido compounds: compounds containing two amido (NH_2) groups or their derivatives.

Diastase—An unformed or soluble ferment which converts starch into sugar.

Digester—See *autoclave.*

Digesting—The process of heating together a solid and a liquid so as to give them every opportunity of reacting with one another.

Distillate—That portion which passes into vapour and collects in the receiver when a substance is distilled.

EFFLORESCENCE—Formation of a powdery deposit on crystals through loss of water or of a powdery crystalline deposit on the surface of a porous body, as in the case of nitre on the surface of the earth in India.

Electrolysis—Separation of a chemical substance into its constituents by an electric current.

Elementary Analysis—The determination of the proportions in which the elements are contained in a substance.

Elutriation—Washing a finely powdered substance, such as clay, by repeated treatment with fresh water.

Endothermic Compounds — Compounds in the formation of which heat is absorbed.

Enzyme—Unorganised ferment.

Equivalent Weights—Weights of substances which will combine with or replace one part of hydrogen. The equivalent weight of a compound will be a simple fraction, usually one-half, of the molecular weight.

Ester—An ethereal salt.

Ether—Usually understood to mean ethyl ether. A highly volatile and inflammable organic liquid ($(C_2H_5)_2O$). The term is also applied to all substances of similar composition, and even to esters or ethereal salts.

Ethereal—Pertaining to ether; thus by an *ethereal* solution is meant a solution in ether.

Ethereal Salts—A salt of an acid in which the hydrogen is replaced by ethyl (C_2H_5) or other radicals, just as a metal replaces the hydrogen of an acid to form metallic salts.

Eudiometer—A gas analysis apparatus.

Excess—A reagent is present in excess when more than sufficient has been added to react with the portion of a substance under examination.

Exothermic Compounds — Compounds in the formation of which heat is developed.

Extraction—Removal of one constituent from a mixture of substances by means of a solvent in which the remaining constituents do not dissolve.

FAT—Natural product composed of ethereal salts, such as glyceryl, stearate, palmitate, and oleate.

Fatty Acids—Acids formed on the saponification of fats. The generic term is now applied to several series of organic acids, including acetic and formic acids.

Fehling Solution—Solution of copper sulphate with Rochelle salt and caustic soda; used in testing for sugars.

Ferment—A nitrogenous organic substance with or without organised structure and power of reproduction.

Fermentation — Chemical process brought about by ferments.

Ferric or Ferri Salts—Salts of iron containing the trivalent iron atom.

Ferrous or Ferro Salts—Salts of iron containing the divalent atom.

Filtrate—The clear liquid obtained by filtration.

Filtration—The separation of a solid from a liquid by passage through a porous medium.

Flask—A globular-shaped vessel of thin glass.

Fluxing—Melting or fusing.

Foots—The deposit of impurities formed in the process of clarifying oils.

Forchammer Process—Determination of amount of acidified permanganate required to oxidise organic matter in a sample of water (water analysis).

Fraction—A portion of a distillate which has passed over during a definite range of temperature.

Free Acid—An acid not in combination with a base.

Free Ammonia (in water)—Ammonia, probably in combination as a salt, sometimes termed *saline ammonia*, and obtained by distilling the water with sodium carbonate.

Free Base—A base not in combination with an acid.

French Chalk—Steatite or soapstone. A hydrated magnesium silicate.

Fusel Oil—Fermentation amyl alcohol formed in small quantities during alcoholic fermentation.

Fusion Mixture—A mixture of equal parts of sodium and potassium carbonates, which fuses at a lower temperature than either separately.

GAS LIQUOR—An aqueous liquor rich in ammonium salts obtained in the purification of coal gas.

Glauber's Salt—Sodium sulphate.

Glucose—See *dextrose*.

Glucosides—Naturally occurring vegetable substances which split up on hydrolysis, yielding glucose and another substance which is not a carbohydrate.

Gluten—A sticky, nitrogenous substance obtained by washing out the starch from wheat flour.

Glycerine or **Glycerol**—An oily liquid with a sweet taste, in reality an alcohol obtained by the saponification of natural fats and oils.

Gooch Crucible—One with a perforated bottom on which is a layer of asbestos so that the precipitate may be filtered, washed, and dried.

Grape Sugar—See *dextrose*.

Graphite—Blacklead; a form of carbon.

Gum—An amorphous carbohydrate characterised by its sticky properties and obtained from the natural exudations of plants.

Gun-cotton—Nitrocellulose obtained by treating cotton with a mixture of strong nitric and sulphuric acids.

Gypsum—Native crystalline calcium sulphate.

HALOGEN—One of the following four elements—chlorine, bromine, iodine, or fluorine.

Hardness of Water — The soap-destroying powder due to dissolved salts.

Homologues—Organic compounds of analogous composition to one another—for instance, methane, ethane, and propane are homologues.

Hydrate—A chemical substance having water in combination with it.

Hydrocarbon—A compound of carbon and hydrogen.

Hydrolysis—A type of chemical decomposition brought about by various agencies, but always accompanied by absorption of water.

Hydroxide—A compound consisting of a metal or radical in combination with hydroxyl groups—for instance, copper hydroxide $Cu(OH)_2$, alcohol or ethyl hydroxide $C_2H_5(OH)$.

Hydroxyl—The group (OH).

Hygroscopic Substance—One which absorbs moisture from the atmosphere.

Hypo—A prefix denoting a smaller proportion of oxygen.

INDICATOR—Substance used to indicate the completion of a reaction in titration processes — for instance, methyl orange.

Infusion—A liquid obtained by treating a vegetable substance with a solvent to dissolve out some of its constituents.

Inorganic Compounds—All compounds excepting those of carbon.

Isomeric Substances—Those having the same percentage composition, but different properties.

Isomerism—The phenomena exhibited by isomeric compounds.

-Ite—The terminal ending of names applied to salts of acids containing less oxygen than those ending in *-ate*.

KELP—The ash of certain seaweeds used as a source of iodine.

Kieselguhr—A porous silicious substance, with absorbent properties.

Kjeldahl Estimation—A method of determining nitrogen, especially in organic substances.

LACTIC ACID—An acid formed in the souring of milk by the action of a ferment on the milk sugar.

Lactose—See *milk sugar*.

Lævo-rotatory—Rotating the plane of polarisation of light to the left.

Lamina—A thin sheet or plate.

Laughing Gas—Nitrous oxide.

Leblanc Process—A method of making washing soda from common salt.

Lees—The deposit at the bottom of a vessel in which wine is fermented.

Lime—Calcium oxide obtained by burning limestone or calcium carbonate.

Liquation—The separation of bodies by heating and allowing the more fusible to melt and flow away.

Liquor—A general term applied to liquids containing dissolved matter.

Litharge—Lead oxide, PbO.

Litmus—A colouring matter obtained from a lichen and used as an indicator.

Logwood—The wood of a tree, which yields a red dye.

Lye—An alkaline liquor containing the caustic alkaloids or their carbonates.

MALTOSE, or **MALT SUGAR** — A sugar produced by the action of diastase on starch.

Marsh Gas—Methane (CH_4); the firedamp of the miners.

Marsh's Test—A test for arsenic.

Measuring Flask—A flask which, filled to a mark on the neck, contains a measured volume of liquid.

Melt—A fused mass of crude product obtained by heating.

Mercuric Salts—Compounds of the higher oxide of mercury (HgO).

Mercurous Salts—Compounds of the lower oxide of mercury (Hg_2O).

Meta—A prefix used to distinguish one isomer from another.

Metal—An element which will combine with oxygen to form a base.

Methane—See *marsh gas*.

Methyl Orange—The sodium salt of an aniline dye; used as an indicator for strong acids.

Microcosmic Salt—Hydrogen sodium ammonium phosphate $HNa(NH_4)PO_4$.

Milk Sugar—A sugar found in milk.

Millon's Reagent—A solution of mercuric nitrate containing nitric acid.

Mineral Acid—This term usually includes sulphuric, hydrochloric, nitric, and other acids of inorganic origin.

Minium—See *red lead*.

Molecule—A word meaning little mass; the smallest particle of gaseous matter that can exist by itself.

Mordant—A substance used in dyeing to aid in fixing the dye on to the fibre.

Must—A crude liquor expressed from fruit.

NATIVE—Occurring in a natural state.

Nessler's Solution—A solution of mercuric iodide in potassium iodide, prepared according to a special recipe. It gives a yellow-brown colour, with even minute traces of ammonia, and a precipitate with larger quantities.

Nitre—Potassium nitrate.

Nitro-cellulose—Nitric esters of cellulose, such as gun-cotton.
Nitro-compound—One containing the nitro group (NO_2).
Nitrometer—A form of gas analysis apparatus used in the estimation of nitrous oxide in vitriol.
Nordhausen Sulphuric Acid—The fuming acid $H_2SO_4.SO_3$.
Normal Acids and Alkalies—Solutions containing an equivalent weight in grammes of the substance in question dissolved in one litre of water at 15° C.,
Normal Solutions — Solutions of standard strength based on a sytem of chemical equivalence.

OLEFINS—A group of hydrocarbons of general formula C_nH_{2n}, where n is any integer; for example, olefiant gas.
Organic Compounds—All compounds of carbon, with the exception of the monoxide and dioxide, which are usually reckoned as inorganic compounds.
Oxidation—The process of adding oxygen or subtracting hydrogen from a substance.
Oxide—A compound of an element or radical with oxygen.
Oxidising Agent—A reagent for adding oxygen to or withdrawing hydrogen from a substance.
Ozone—A form of oxygen containing three atoms to the molecule.

PARAFFINS—A group of hydrocarbons of the general formula C_nH_{2n+2}, where n is any integer; for instance, marsh gas (CH_4).
Pearlash—Calcined potassium carbonate.
Permanent Hardness—Hardness of water not removed by boiling, and generally due to the presence of dissolved sulphates.
Permanent White — Precipitated barium sulphate.
Peroxide—An oxide containing more oxygen than the common oxide.
Phenol—Carbolic Acid (C_6H_5OH).
Phenol-phthalein—An organic synthetic dye stuff used as an indicator for weak acids.
Pickling—A term applied to the process of soaking a solid in a liquid.
Pinch-cock—A spring clip for closing a piece of indiarubber tubing.
Pipeclay Triangle—Three pieces of clay pipe-stem held with iron wire, and used for supporting crucibles.
Pipette—Graduated glass tube for measuring liquids.
Plaster of Paris—Hydrated calcium sulphate or gypsum, from which part of the water has been removed.
Plumbago—Blacklead or graphite, a form of carbon.
Potash or **Caustic Potash**—Potassium hydroxide.
Precipitant—A substance used to bring about the formation of a precipitate.
Precipitate—A solid substance formed in a solution by a chemical reaction.
Proof Spirit—An antiquated and cumbrous standard of strength for alcohol. The density of proof spirit works out to ·91984 at 60° F. It contains 49·24 per cent. of alcohol by weight.
Protein—See *Albuminoids*.
Proximate Analysis—The determination of the ingredients in a mixture.
Prussian Blue—A pigment formed of complex cyanides of iron.
Pyrites—Native sulphides of iron, and of iron and copper.
Pyrolusite—A mineral containing crude oxide of manganese.

QUALITATIVE ANALYSIS — The process of ascertaining the nature of the constituents of a substance.
Quantitative Analysis—The process of ascertaining the proportions of the constituents of a substance.
Quartz—Crystalline silicon oxide or silica (SiO_2).
Quicklime—Calcium oxide (CaO).

RADICAL or **RADICLE**—A complex group of elements playing the part of, and reacting as, a single element.
Reaction—The chemical action of one substance on another.
Reagent—A substance, generally in solution, used to bring about a characteristic chemical reaction.
Red Lead or **Minium**—The oxide of lead (Pb_3O_4).
Reducing Agent—A reagent for adding hydrogen or abstracting oxygen from a substance.
Reduction—The process of adding hydrogen or withdrawing oxygen from a substance.
Reichert's Process—The standard method for estimating volatile fatty acids in butter.
Resin or **Colophony**—A resinous substance left in the retort after the distillation of crude turpentine.
Resins—A class of vegetable solids of brittle and glass-like fracture.
Rider—A small V-shaped wire which is shifted from one position to another on the beam of a balance, instead of putting weights into the pan.
Rochelle Salt—Sodium potassium tartrate.
Rock Crystal—Quartz.
Rock Salt—Native sodium chloride or unrefined common salt.
Rouge—Finely ground ferric oxide (Fe_2O_3).

SALINE—Partaking of the nature of a salt.
Saline Ammonia (in water).—See *free ammonia*.
Salt—Generic term for the product of the combination of an acid with a base.
Salt Cake—Crude sodium sulphate; the first stage in the manufacture of soda by the Leblanc process.
Sampling—The operation of removing a small portion or sample representative of the whole.
Sand Bath—A shallow metal tray containing a layer of sand on which vessels may be heated.
Saponification—The process by which a soap (metallic salt of a fatty acid) is obtained from a fat. The term is applied also to the hydrolysis of any ethereal salt with the formation of an alcohol and a fatty acid or its salt.
Saturated Solution—A solution containing as much substance dissolved in it as the liquid will take up.
Semi-normal—One half of normal strength.
Silicious—Composed of, or partaking of the nature of, silica or sand.
Slag—A fusible silicate formed in the process of obtaining metals from their ores.
Slaked Lime—Lime slaked; that is, treated with sufficient water to form calcium hydroxide.
Smelt—Cobalt blue. A silicate of cobalt.
Soap—The metallic salt of a fatty acid, generally oleic, palmitic, or stearic, or a mixture of these.
Soda Lime—A mixture of soda and lime, used for absorbing carbon dioxide gas.
Soft Soap—A potash soap or potassium salt of a fatty acid, hard soaps being sodium salts.
Solvent—Liquids used for dissolving substances.
Soxhlet Apparatus—An automatic apparatus for the extraction of fatty substances with volatile solvents.
Specific Gravity—The ratio of the weight of a substance to the weight of an equal volume of water.
Standard Solution—Solution of definite strength, usually normal or decinormal.
Steam Oven—An oven surrounded by a steam jacket.
Still—Distilling apparatus.
Suction Gas—See *water gas*.
Sulphonic Acid—An organic acid containing the group SO_2H.
Superphosphate—A manurial substance containing monocalcium phosphate.
Synthesis—The building up of a compound from its elements, or from simpler substances.

TALC—A substance of similar composition to French chalk.
Tartar Emetic—Potassium antimony tartrate.
Temporary Hardness—Hardness of water removed by boiling, and due to bicarbonates. See also *hardness*.
Thermometric Scales—Those commonly used are the Centigrade and Fahrenheit scales.
Thio—A prefix showing that oxygen in the substance has been replaced by sulphur.
Tincal—Crude borax.
Titration—The process of adding a measured amount of a solution of one substance to another until the reaction between them is complete.
Turmeric—Yellow colouring matter.
Twaddell Degrees — A technical method of reckoning the specific gravity of a liquid. Thus, Degrees Twaddell $= \frac{\text{specific gravity} - 1{,}000}{5}$, water $= 1{,}000$

ULTIMATE ANALYSIS—The separation of substances into their constituent elements.
Ultramarine — An artificial blue colouring matter resembling ground lapis lazuli.
U-tube—Glass tube in the shape of the letter U, and used for absorbing gases.

VACUUM DESICCATOR—A desiccator from which the air can be exhausted.
Valency—The combining capacity of an element or the number of hydrogen atoms or their equivalents with which an atom of the element in question will combine.
Vermilion—Sulphide of mercury; used as a pigment.
Vitriol—Sulphuric acid.

WASH-BOTTLE — Bottle or flask with which a jet of water can be directed on to a precipitate for the purpose of washing it.
Washing — Treating a substance (usually a precipitate) with successive quantities of a solvent, such as water, in order to dissolve soluble impurities.
Water Gas—A mixture of hydrogen and carbon monoxide gases obtained by passing steam over red-hot coke.
Water Oven—*Steam oven*.
Wax—An ethereal salt of a fatty acid, and a monohydric alcohol (alcohol with a single hydroxyl group).
Weighing-bottle—A small stoppered bottle in which a substance can be weighed out of contact with the surrounding air.
Welldon's Process—A process for the recovery of manganese from still liquors, and hence indirectly a method for making chlorine.
White Arsenic or **Arsenic**—Arsenic oxide (As_2O_3).
White Lead—Basic carbonate of lead.

YEAST — A vegetable (organised) ferment which is capable of converting sugar into alcohol.

ZINC WHITE—Zinc oxide (ZnO).

CIVIL ENGINEERING

SEE ALSO MECHANICAL ENGINEERING AND MINING

ABUTMENTS—Masses of masonry or natural rock, upon which the ends of a bridge are supported.
Adit—Subterranean passage or gallery.
Air-lock—Chamber with ingress and egress doors for workmen passing into workings where water is excluded by pneumatic pressure.
Ajutage—Tube fixed at the mouth of a hydraulic vessel to regulate water discharge.
Alignment—The setting of two or more planes, or three or more poles or points, in one straight line.
Alternate Stresses—Stresses by which structures, or parts of structures, are placed alternately in tension and compression, as in counterbraced structures, subject to moving loads.
Anchor and Collar—Hinges employed in hanging lock gates.
Apron—A protection of concrete or other material to prevent the scouring effects of running water.
Ashlar—Blocks of stone cut to regular shapes, generally rectangular.
Attle—Any rubbish or stony matter.

BACK SIGHT—The first reading upon setting up a level in a new position.
Balance Box—Box which counterbalances the load lifted by a crane, usually a cast-iron box loaded with scrap iron or kentledge.
Banker—Bench or table on which masons prepare and shape their materials.
Bare—A term which signifies that a dimension is very slightly under the size preceding the term.
Barrage—The barring of a river or other watercourse to bank up the water behind.
Barring Engine—An engine used for the initial turning of larger engines.
Barrow—Receptacle for carrying earth or other material.
Bascule—A bridge lifting in two leaves hinged to the abutments.
Batter—Face of a retaining wall when built in a leaning position.
Bay—In a lattice girder, the space included between two adjacent apices is called a bay.
Beaumonteque (baum-antik) — Any mixture for stopping holes in stone or woodwork.
Benches—Platforms about 6 ft. in width on the sides of cuttings.
Benching—Is cutting steps in the sloping surface of earth before filling in behind a retaining wall.
Bench-mark—A recorded point in a survey, either marked on the ground or described in the field book or level book.
Berm—Narrow strip of level ground along the face of a slope.
Betty—An iron rod used as a crowbar.
Bight—The hanging loop of a chain or rope which falls below the pulleys in lifting tackle.
Block and Fall—The rope tackle used in lifting heavy loads.
Bollard—Post of cast iron or timber, to which vessels are moored.
Bolster—Short piece of wood interposed horizontally between head of post and supported beam.
Boning Staff—Upright rod with a cross bar at right angles; used for adjusting intermediate points of levels and gradients.
Bonnet—Hole formed in iron pipes and fitted with lid.
Boom—A term applied to the mast or girder of a derrick crane, and the flanges of a large girder.
Booms—Pieces of timber connected with fender piles to protect cofferdams.
Bowstring Girder—A girder in which the outward or horizontal thrust of a curved beam is sustained by a horizontal tie beam forming the chord of an arc.
Braces—Diagonal pieces used in the centre portion of a truss.
Break Up—Excavation begun from an underground passage or gallery and carried upwards.
Breast-wall—A wall at the foot of an embankment cutting off the toe, or any wall breast high.
Broach—A boring tool, employed for the purpose both of enlarging and imparting accuracy to tapered and parallel holes.
Brob—Wrought-iron spike driven into bars or sills, around the ends of props, to steady them.

CAISSON—Water-tight enclosure, built up as required, to surround foundations under water.
Camber—The bow or upward convexity of material to allow for deflection.
Cantilever—A beam fixed at one end and loaded at the other end, or loaded uniformly.
Cess—The space between the top of a railway embankment and the boundary fence.
Channel-bar—A double-angle section of wrought iron or steel used in framework.
Check—A joint composed of two portions, male and female, fitting one into the other, and so forming a guide or steady.
Chute—An enclosed trough which conducts the water to a water-wheel.
Cleading—Covering of planking or iron plates to strengthen tunnel sides in loose ground.
Cleat—A block of wood which furnishes a steady point of attachment for a part of a structure.
Closer—A brick cut in half longitudinally.
Coffer-dam—Water-tight enclosure of piling or of cast-iron plates bolted together; used in building piers to keep water out of work.
Continuous Beam—A beam which rests on more than two supports.
Coping—A covering of impervious material on the top of a wall, or the curb at the edge of a dock.
Corbel—Short piece of wood interposed horizontally between the head of a post and a supported beam. Also a short cantilever.
Counterbracing—Diagonal bracing introduced into a truss or girder for the purpose of giving additional support.
Counterfort—Projection from the back of a retaining wall, added to increase stability.
Course—A continuous range of stones or bricks, of uniform height, in a wall.
Crab—Small portable crane to raise material.
Cradle—The end girders of overhead travelling cranes which carry the running wheels.
Cramp—Metal tie used for uniting the several stones of a wall.
Creeper—Iron instrument like a grapnel, with four claws, for dragging the bottom of a harbour or river to find anything lost.
Crib—A timber construction filled with rubble stone.
Crib-work—Series of layers of logs, laid alternately lengthwise and crosswise, notched and pinned to each other at their intersections.
Cross Bracing—Diagonal bracing introduced into a framed structure for the purpose of preventing lateral movement.
Crutch—Piece of timber in the shape of a bent knee.
Cuddy—Three-legged stand forming a fulcrum for lever in lifting stones or heavy weights.
Culvert—A drain carried under a road or railway.
Curb—Suitably formed ring of brickwork or cast iron at the base of a shaft, surmounting a circular orifice in the roof of a tunnel.
Cushion—Stone situated upon the top of a pier upon which an arch is built.
Cut and Cover—The operation of making a cutting, building a tunnel in the opening, and then replacing the covering material.
Cutters—Bricks of special quality for cutting to shapes.
Cutwater—Lower portion of a pier separating two arches of a bridge.

DAM—An earthen or masonry wall to retain a body of water, as in an impounding reservoir.
Dead Neap—A very low tide.
Derrick—A form of crane in which the radius of the jib is rendered capable of alteration by means of chains or guys passing over the top of the mast.
Digger—Apparatus used for mechanically excavating earth, etc.
Dike—Term sometimes used in the same sense as embankment.
Distress—A beam or structure is in distress when it is subject to undue or excessive stress, or to an amount exceeding the working stress.
Dolly—Intermediate short post of timber used in pile-driving.
Double Butt Strips—Two covering strips employed in making a butt riveted joint, one strip being placed on each side of the abutting plates.
Dressing—Slopes of embankments and cuttings dressed to a smooth and regular surface.
Drift—Small horizontal or inclined underground passage.
Drove—A narrow channel or drain.
Dumby—A floating barge connected with a pier.

END PILLAR—The vertical part of a lattice girder immediately over the supports.
Enrockment—Term applied to the stone filling upon breakwaters, banks of rivers, etc.
Extrados—The outside or upper surface of an arch.

FACE—Surface exposed by excavation in tunnelling.
Fair—Parts are said to be flush or fair when their surfaces are on the same level.
Fatigue—When the stress exceeds the elastic limit, intermittently or permanently, there is a progressive loss of strength, ending in failure.
Female—The recessed protion of any piece of work into which a dowel or projecting piece fits.
Fender Piles—Timbers placed in front of quay walls.
Fish-bellied—Girders and ribs are said to be bellied, or fish-bellied, when they are curved underneath, the depth of curve increasing towards the centre.
Fish-bolt—A bolt employed for fastening fish-plates and rails together.
Fished Beams—Beams joined by fish-plates.

Fish Pieces—Pieces of wood or iron connecting two pieces of a tie in a fished joint.
Flanks—The sides of an arch.
Flank Wall—The side wall of a building.
Flashes—A description of sluice.
Flitch-plate—A plate of metal bolted between two timber flitches to strengthen them.
Floating Clough—Movable dam or machine used for scouring out inlets.
Floating Derrick—A derrick crane placed on board a floating hull for transferring goods to and from vessels, independently of proper wharf and dock accommodation.
Flow—The condition of a tidal river when running up. A rising tide.
Fluffy—Timber is said to be fluffy when the sawdust is stringy and moist or greasy instead of granular and sharp.
Flush Bolt—A bolt whose head is let into a recessed hole so that its top face stands level with the face of the material into which it is sunk.
Foot blocks—Flat pieces of wood placed under props to give a broad base.
Foresight—The last reading at a level before shifting the instrument.
Formation Breadth—The width of the bed of a railway below the ballast.
Formation Level—The level of a road or railway prepared for the road metal or ballast.
Four-foot—The space between a line of rails over which the traffic runs.
French Drain—A chalk or rubble drain at the back of a retaining wall.
Full—A term which signifies that the dimension is very slightly over the size preceding the term.
Full Way—A waterway is said to be full when the area of the opening in the valve, or plug, as the case may be, is equal in extent to the area of the pipe.

GAD—Wedge of steel for driving into crevices or openings made by pick or chisel.
Gallery—Same as *Drift*.
Galletting—Small splinters of stone inserted in the joints of coarse masonry.
Gantry—The trussed beams, or girders, as the case may be, which carry the crab or crane in overhead travelling cranes; also the timber substructure.
Gibbet—The triangular framework of a crane, consisting of post, jib, and strut.
Gin—A rude, portable, yet effective hoisting machine of the well-known tripod form, from whose apex the pulleys and gin-blocks for lifting are suspended for working heavy tackle. A barrel and winch are fixed between the two legs which form the shears.
Gin-block—A single-sheave pulley of a hollow-rim section, having its bearings in a skeleton frame suspended from a hook. A rope is passed over the pulley, one end of which is held by a man, the load being attached to the opposite end.
Goliath—A travelling crane supported on high trestles moving upon rails.
Grab—A skip or bucket with movable clam jaws, hung from a crane for lifting coal, ballast, etc., without manual labour.
Gradient—The slope of a road, railway, sewer, etc. Stated as 1 in —, according to the horizontal feet distance to reach a change of level of one foot.
Gridiron—A simple framework of timber placed to admit of vessels being floated above it at flood tide and grounded upon it during the ebb for the purpose of examination.
Grillage—Term applied to sleepers and cross beams supporting a platform; also to foundations of rolled steel joints and concrete.
Groyne—A timber framework constructed across a beach between high and low water mark in order to prevent portions of the beach being washed away.
Ground Moulds—A portion of the framework used in tunnelling to guide the bricklayers.
Ground Square—Two straight-edged strips of board the ends of which are so united as to form a right angle.
Grout—Liquid mortar used for running into dry joints in brick or stonework.
Gullet—Small preliminary working cutting about 15 feet wide.
Gusset—An angle-iron bracket used to stiffen an angular portion of a structure.
Gusset Plate—A joint plate in roof and girder work.
Guy—A rope or chain from the top of a derrick pole or shear legs to keep them steady.

HAUNCH—That part of an arch between the keystone and the springing.
Header—A brick placed with its greatest length at right angles to the face of a wall.
Heading—Small horizontal or inclined underground passage driven in advance of the full-sized excavation.
Hedgehog—Machine for removing mud and silt from rivers and streams.
Heel—The thick or broad end of a wedge-shaped piece of wood or iron.
Heel Post—The vertical member at the shore end of a lock-gate, with a pivot at top and bottom upon which it swings.
Hoggin—Small sifted gravel.
Hollow Quoins—Cylindrical recesses in which gates of locks, etc., are hinged.
Horn Plate—The upright frames in which axle boxes slide.

IMPACT—The sudden fall of a load upon a beam or structure. The deflection of beams varies nearly as the velocity of impact.
Impact Wheel—A water-wheel which is driven by the percussive force of water acting at right angles to the floats and at a tangent to the circumference of the wheel. Turbines are impact wheels.
Imposed Load—The load which is extraneous to a structure, and distinguished from that due to the structure itself.
Impost—A sort of capping at the top of a pier supporting an arch.
Impulsive Load—A load applied suddenly to a structure. The structure is thus subject to the accumulation of energy due to the impact of the load, or that gathered in its motion, in addition to its actual dead weight.
Indifferent Equilibrium—The equilibrium of a body which is neither stable nor unstable. If, when a body is moved longitudinally, the centre of gravity moves in a horizontal line, as in a sphere, the equilibrium is said to be indifferent.
Internal Stress—Stress set up in the internal portions of castings, and due to unequal contraction caused by differences in their mass.
Intrados—The under side of an arch.
JIB—The strut or thrust member of the framing of a crane. It is always in compression.
Jib-legs—Timber legs pivoted to the jib pin of a crane. Reaching to the ground, they afford a firm and broad base to the jib when lifting, and so prevent the crane from overturning. When not in use they are shipped over the side frames
Jim-crow—A portable rail-straightener or rail-bender.
Joggle—Keys of hard wood, or other material, used to resist shearing stress at the junction of two beams by being let into the surfaces, the beams being fastened together by vertical bolts in the spaces between the keys.
Journal—The portion of a rotating shaft which is in contact with its bearing.
Jumper—Long iron instrument with sharp steel point for making holes in rock or hard ground.

KENTLEDGE—The loose balance-weights supplied with a balanced crane.
Key—The wedge used to fasten the rail in the chair on railways.
Keystone—Highest stone in the centre of an arch.
King Post—The central upright in a roof truss, against which the rafters abut, and which supports the tie beam.
King Truss—A truss formed with a king post.
Knuckle Joint—A joint in which an eye at the end of a rod is embraced by the forked end of a second rod, the two being connected with a joint pin.

LAP JOINT—A joint produced by the overlapping of contiguous faces of metal.
Lattice—Diagonal bracing forming struts and ties.
Lattice Web—A girder web made by lattice bars, as opposed to a plated web.
Leading-frames—Framework formed to guide bricklayers in making brickwork tunnels.
Leat—Artificial channel for conducting water to water-wheels.
Lengths—Successive sections in which a tunnel is executed.
Lewis—Truncated iron wedge or dovetail, used with larger end downwards, for lifting stones by chains.
Life—Expressive of the total period during which a structure remains efficient.
Life-wall—Cross-wall of a back chamber in a tunnel.
Lining—Term applied to puddle clay reduced to a semi-fluid state, and laid along the bottom and sloping sides of canals, etc.
Lockage—Expenditure of water in passing boats from one level to another.

MALE—When a stud or a dowel fits into a recess it is said to be the male portion of that particular piece of work.
Meeting Post, or Mitre Post—The vertical member of a lock-gate where it meets the other gate.
Metalling—Term applied to the covering of roads generally.
Mitre Joint—A butt joint whose ends are cut at an angle of 45 degrees, the abutting sides therefore forming an angle of 90 degrees.
Monkey—The clip hook which lifts and releases the ram in pile-driving.
Monkey-engine—Apparatus used in driving piles.
Monkey Wheel—See *Gin-block*.
Mushroom—Horizontal single sheaves which act as leads for a rope to a capstan.

NEEDLE—Set of square bars of wood used for opening flood-gates in a weir.

OFF-LETS—Pipes placed at the level of the bottom of a canal and fitted with sluices.
Overshot Wheel—A water-wheel which is turned by the gravity or weight of the water emptying itself into buckets at the top of the periphery.

PENSTOCK—A sluice or flood-gate.

Permanent load—A load which is constant and unvarying and a dead load, as the weight of a structure itself, or a load imposed thereon, or both taken in conjunction as distinguished from a live or a rolling load.

Permanent way—The road bed and rails upon which trains are run.

Pile hoop—An iron band, shrunk on the head of a pile to prevent splitting of the timber while being driven in.

Pinch bar—A bar of iron, or wood shod with iron, used to move heavy loads for short distances by "pinching" them along.

Pitch—Inclination which the sides of a roof make with the horizontal.

Polings—Planks or deal ends, by which the sides of an excavation are supported.

Proof load—A load imposed on a structure greater in amount than the working load, in order to test its capability or margin of safety. The deflection of a structure, when under its test load, is carefully noted and its capability deduced therefrom.

Props—Struts or posts, either vertical or raking, used as supports in tunnelling.

Puddle—A mass of tempered clay, to prevent the passage of water.

Punch—Same as *Dolly*.

Purlins—The members which unite the trusses of roofs in longitudinal directions.

Putlogs—Short poles used for scaffolds.

QUEEN POST—A roof member which fulfils a similar function to that of the king post, its position only being different. Used in pairs.

RABBET, or REBATE—A shoulder or recess on the edge of a piece of wood or metal for the reception of the edge of another similar piece.

Race—Cut along which water is conveyed to and from a water-wheel.

Rail gauge—The width in the clear between the two adjacent sides of the top flanges of the rail upon railways.

Rakers—Same as *Props*.

Ram—Heavy weight dropped on to piles when they are being driven.

Ranging—Laying out the line of a tunnel.

Retaining wall—A wall to hold up a bank of earth, usually battering on the face.

SCARFING—Method of connecting ties or beams, the ends of the two pieces overlapping.

Scouring power—Stream of water employed in connection with harbours to carry away the shingle, etc., to prevent its accumulation at the mouth.

Scuttling—Method of stirring up deposits by mechanical means.

Semi-beam—A beam fixed at one end and loaded at the other or loaded uniformly.

Shearing stress—The stress to which a body is subject when force is applied to it in a direction parallel with its section. Its mean intensity is equal to the shearing force divided by the area of the section.

Shear legs—A rude but strong form of crane, having three legs or pillars of timber or iron, set leaning at an angle towards each other for supporting the lifting tackle. The gear wheels may be attached to one of the legs, or be fixed independently, and hand or steam power may be employed.

Sheet-piling—Row of timbers or piles driven firmly, side by side, into the earth.

Shoe—A cap, or socket, which receives the end of a piece of timber and which sustains the end pull of a truss rod, or takes the thrust of the legs of shears, or carries a pivot or bearing as in pillars of wooden cranes, or acts in a general way as a protection to timber ends, as in pile shoes.

Shore—Pieces of timber placed diagonally against walls, to support them.

Shoulder—That portion of a shaft or a flanged structure where an immediate increase of diameter occurs.

Sills—Strong timbers of large dimensions, placed horizontally across the line of a tunnel to support the props, etc.

Side width—The distance required from the centre line to form a road or railway.

Silt—The alluvial soil washed down and deposited on the bottom and sides of rivers by the action of the tides.

Six-foot—The space between two railway tracks.

Skew-back—Large stones cut to an angle to receive the end of an arch.

Skin-dam—A dam consisting of a single row of sheeting piles of whole or half timber, with tiers of horizontal wallings or planks.

Slurry—Liquid mud or cement mortar.

Soffit—The under side of an arch.

Sough—A small drain, situated at the top of an embankment.

Span—The clear width between the supports of a girder or arch.

Spandril—The portion on the top of a pier between one arch and another.

Spider wheel—A wheel or pulley having light arms of wrought iron or steel.

Spoil, or spoil bank—The surplus material excavated, which is laid by the side of a railway or canal.

Spoon and bar—Tool used in hand-dredging.

Spot Levels—Detached levels taken over a wide area, or at certain irregular positions.

Springing-line—The line in which the soffit of an arch intersects the pier.

Staiths—Short tongues or jetties used for coaling.

Starling—The angular form of a pier-head in bridge work.

Stirrup—A strap which supports a beam or sustains the thrust from one end of a strut.

Strain—The change of form produced in a body by a stress.

Stop-planks—A description of dam employed on canals.

Stress—When materials and structures are subjected to straining forces those forces are resisted by internal molecular actions called stresses. transverse, shearing, or torsional.

Stretcher—A brick with its greatest length placed parallel with the face of a wall.

Striking-plate—The apparatus by which the centre is lowered after the arch of a bridge has been completed.

Struts—These may be vertical or diagonal and connect a beam with a truss rod. Through them the strains due to deflection of the beam are translated into those of tension in the rod. In roof trusses those members which extend diagonally from the beam or from the foot of the king post or queen post either to the rafters or to the shoulders of ths queen posts.

Surcharged wall—A retaining wall to hold back a bank of earth sloping upwards above the top of the wall.

Sump—Hole at the bottom of excavations into which water is drained, and in which the end of the suction pump is placed.

TAIL—The hinder part of a portable crane upon which the balance box rests.

Tee-bars—Rolled wrought iron or mild steel bars whose section is that of the letter T. They are employed in engineering constructions such as bridges, girders, and roof work.

Teeming—Depositing earth in an embankment.

Temoin—Earth pillar left in excavations.

Tenon—A tongue projecting from the end of a piece of timber, and which, with the mortice into which it fits, is one of the common joints in woodwork.

Terring—Scotch term for soil removed in clearing the top of a quarry.

Thimble—Ring attached to a buoy.

Thirl or thirling—Meeting of workings approaching each other from opposite directions in tunnelling.

Thorough—A term applied to the longer heading stones forming a wall.

Thrust—The compressive force exercised by a body transmitting pressure.

Tine—An iron or steel claw used in dredging operations.

Toggle—A bar of iron or wood used to tighten a chain or rope by twisting two lines together.

Tongue—This is a short piece of metal or wood projecting from one portion of a structure and entering into another, in order to ensure steadiness and to prevent overlapping of joints.

Transom—Horizontal framing in bridge work.

Traveller—A framework carrying a lifting crab and able to travel along elevated rails.

Trenail—Wooden pins of large diameter used as fastenings for joints.

Trig station—A place where a theodolite is set up for the purpose of taking an observation.

Truss—Triangular frame in bridge and roof work.

Tunnel—A passage lined with brickwork or masonry, excavated through a hill or below the surface of the ground.

ULTIMATE STRENGTH—The load which produces actual fracture in a structure.

Underpinning—Additions and repairs to foundations and walls in which the latter are first supported by strong timber shores and needles.

VOUSSOIRS—Wedge-shaped blocks forming the arches in bridge-building.

WALES—Horizontal braces.

Waling—A horizontal piece of timber used to hold vertical pieces in place either in an excavation or against a jetty.

Warren girder—A lattice girder in which the struts and ties form triangles or triangular bays, the struts leaning inwards or towards the centre of the girder, and the ties leaning outwards. A Warren girder consists of a single system of triangles, while lattice girders contain two or more systems of triangulation.

Web—The plated or central portion of a structure as distinguished from its flanges and bosses. Thus, a crank web is the plate which carries the shaft and pin bosses; a girder web is the main vertical plate which becomes the connection between the top and bottom flanges.

Weep-hole—A hole for drainage made through a retaining wall or bridge abutment.

Wind Bracing—Horizontal diagonal bracing under footbridge.

Wrinkling—The failure of thin unstayed or improperly stayed plates, by wrinkling up or becoming corrugated under pressure.

TRANSIT

SEE ALSO MOTOR ENGINEERING

ARTILLERY WHEEL—A wheel with wooden spokes mitred together at the centre. The hub consists of two face plates, one of which is in the solid with the box through which the axle arm passes.
Automatic Valve—One which is opened by suction and closed by a spring.

BIG END—The bearing of the connecting rod on the crank pin.
Bogie—A four or six wheeled truck free to move on a central pivot; used under railway carriages and tramcars.
Bolster—An under-carriage member, usually taking the bearing on which it turns.
Bonnet—The engine cover.
Bore—The internal diameter of the cylinder.
Brake, Contracting—A metal strap passing round a drum for retarding the car.
Brake, Expanding—Metal shoes arranged to press internally against a drum.

CABRIOLET—A motor body with head and driver's canopy both folding. The body is fully equipped with glass frames.
Camshaft—The shaft carrying projections which cause the engine valves to rise.
Cant—The plan of the body which shows the side-sweep, turnunder, bevels, and joints of the framing.
Cant-rail—The member which joins the tops of the pillars.
Cape Cart Hood—A waterproof covering supported on wooden hoops. The "one-man" hood works from one pair of body centres.
Carburetter—The device which converts the petrol into a fine spray, and ensures the proper mixture of air for the subsequent explosion.
Cardan Shaft—The member which transmits the power from the gear box to the back axle.
Change Speed Lever—The inner hand lever which, by its movements in the gate, brings the proper wheels in mesh within the gear box.
Chassis—The mechanism of the car.
Clerestory—An additional headroom beyond the roof proper.
Clip—The fastening of the spring to the axle.
Clutch—Usually two cone-shaped members which are engaged by pedal for transmitting the power of the crank-shaft to the gear box.
Compression—The action of the piston in pushing a cylinder full of gas into the head of the cylinder.
Connecting Rod—The member which converts the reciprocating action of the piston into circular crank-shaft motion.
Cooling—The water jacketing of the cylinder. The circulation may be carried out by pump or by the natural upward flow of heated water.
Cylinder—The hollow vessel in which the piston works.

DASH—The division between engine and bodywork.
Differential Gear—A device which connects the halves of a live axle, enabling the hind road-wheels to travel at independent speeds.
Direct Drive—Power transmitted independently of the gear box.
Double Deck—A vehicle provided with roof seats.
Dual Ignition—Ignition provided for by coil and accumulator as well as by a magneto.

EXHAUST PIPE—The pipe carrying the spent gases from the exhaust valve to the silencer.

FELLOE—A curved section of a wheel rim, usually carrying two spokes.
Filling Up—Paint applied to fill up the pores of the panel and provide a foundation for subsequent coats.
First Speed—The slowest speed.
Flatting—Removing the gloss of a varnish coat.
Fly-wheel—The wheel keyed to the back of the crankshaft forming one member of the clutch.
Frame—The pressed steel members which carry the engine and transmission gear, and form the foundation for the body.

GATE—The device near the foot of the change speed lever which guides it so that the selector mechanism operates the proper gears according to the speed required.
Gear Box—The receptacle, usually just behind the clutch, sometimes on the back axle, which contains the change speed mechanism.
Glass-frame—The frame in which a fixed or moving window, or light, is retained.
Glass-frame Carriers—Metal channels for holding a glass-frame above the top of a half door.
Gudgeon Pin—The shaft on which the connecting rod swings in the head of the piston.

HALF-DOOR—A door carried to the waist of the body and not to the roof; used in landaulettes and cabriolets.
Head—The folding leather covering of a landaulette.
Headstock—The front and hind bars of a railway vehicle bottom framing.
Hoopstick—A roof-carrying member.

LANDAULETTE—A side-entrance body, with driving seat and an enclosed hind seat having a folding leather hood.
Lamps—Head lamps are fastened at the front of the car, and side or dash lamps at the dash or front of the body; the tail light is fitted on the off side at the rear if the car is to be used on British roads.
Light—A window.
Limousine—A side-entrance body with driving seat and an enclosed hind seat furnished with side lights.
Limousine-landaulette—As above, but the enclosed portion has a folding leather hood.
Lubrication—System of forcing oil to important bearings by means of a pump geared to the engine.

MAGNETO—A device consisting of horseshoe magnets in which an armature, geared to the engine, revolves and generates current.
Mixture—The combination of gaseous petrol and air.

NEUTRAL GEAR—Idle revolutions of the gears which are arranged by the side lever when the car is stationary, but not the engine.

OBSERVATION CAR—A railway coach designed for look-out purposes.
Odometer—An instrument for measuring distance.
Omnibus—A closed vehicle to carry passengers, often with roof seats.

PHAETON—An open body.
Pillar—An upright member of the framing.
Piston—The cylindrically shaped body which slides up and down in the cylinder.
Piston Ring—A metal collar placed round the piston to render it more gas-tight.
Poppet Valve—The common type of valve, shaped like a long-stalked mushroom.
Propeller Shaft—Cardan shaft, *q.v.*
Pullman—(1) A luxurious railway coach with independent seating; (2) a fully enclosed motor body without partition between driver and other occupants.

RADIATOR—The device—usually in front of the bonnet, but sometimes in front of the dash—for cooling the circulating water of the cylinder jackets.
Radius Rod—A hinged rod which resists the tendency of the back axle to move forward independently.
Rave—The upper horizontal members of a van side framing.
Rim—The metal band which retains the rubber tyre; also one of the wooden members when the periphery of the wheel is in two parts only.
Rocker—A panel below the seat line or body side.
Rubbing Down—Smoothing the filling up with pumice-stone and water.

SALOON—(1) A railway coach with long side seats; (2) a Pullman motor body, *q.v.*
Scuttle—A dash with side and top panels.
Shackle—The joint which allows a spring to lengthen or contract.
Shock Absorber—A device fitted to a spring which absorbs secondary shocks.
Side Sweep—The external horizontal curvature of the body.
Silencer—The final receptacle for the exhaust gas.
Single Deck—Having no roof seats.
Sparking Plug—A porcelain member screwed into the cylinder head, which carries the ends of the high tension wire across which the exploding spark passes.
Speedometer—An instrument for registering the number of miles per hour travelled.
Spring—The elastic member between frame and axles.
Standard—The side pillar of a van.
Standing Pillar—One which embraces a doorway.
Steering Column—This contains a rod which conveys the movements of the steering wheel to the two arms of the front axle.
Stroke—The travel of the piston.

TARE—The unladen weight of a vehicle.
Tilt—A van cover.
Torpedo—A motor body having flush sides.
Trimming—Upholstery.
Tulip—A turnunder in which a straight profile develops at the top into an outward sweep.
Turnunder—The contraction of a body downwards.

UNIT CONSTRUCTION—The assemblage of important chassis components so as to simplify suspension.

VACUUM BRAKE—A brake applying its power by the destruction of a vacuum.
Valve—The device whereby gas is admitted to or expelled from the cylinder.
Van—(1) A four-wheeled trade vehicle; (2) a closed, non-passenger railway vehicle.

WASTING—The rabbet in the framing round a light.
Westinghouse Brake—A brake applying its power by the lowering of atmospheric pressure.
Wheel Base—The distance between the two axle centres.
Wheel Track—The distance between the tyre centres or treads.
Wing—A mudguard.

AERONAUTICS

AERODROME—A flying-ground. Literally, an "air-running."

Aerofoil—The curved wing of an aeroplane, commonly called a "plane." Derivatively, an "airleaf."

Aero-hydroplane—A hydroplane boat fitted with wings so that it flies after reaching a sufficient speed as a hydroplane or skimming-boat.

Aero-motor—An internal-combustion engine designed to be specially light for aircraft.

Aeronautics—The science of aerial navigation.

Aeroplane—A flying-machine propelled by its own engine, the said machine being heavier than air, and supported on wings (or planes).

Aileron—A flap fitted to the tip of an aeroplane wing to control the lateral balance.

Aircraft—Generic term for airships, aeroplanes, and balloons.

Airman—One who possesses extended knowledge of the air and its habits, just as a "seaman" must have experience and knowledge of the sea. Not necessarily an "aviator" or a "pilot."

Air-screw—A revolving helix, generally of wood, driven by an engine to draw or push an aeroplane through the air, exactly as a screw-propeller drives a boat through the water.

Airship—A dirigible balloon, the balloon being generally cylindrical, sausage-shaped, or cigar-shaped, propelled by engines carried in a car (or gondola or nacelle), or cars, slung underneath the balloon.

Anemometer—An instrument for measuring the speed of wind.

Aviatic—Pertaining to aviation (occasionally used).

Aviation—That portion of aeronautics dealing with flying-machines (or aeroplanes) as distinct from airships (or dirigible balloons).

Aviator—One who practises the art of aviation. Correctly applied only to a person holding the "aviator's certificate" issued by the International Aeronautical Federation, represented in the British Empire by the Royal Aero Club. See *Pilot*. Not necessarily an "airman."

BALANCING FLAP—An alternative name for an aileron.

Ballonet—Small air-bags inside an airship, which are inflated with air forced in by a pump to keep the main envelope fully distended. Occasionally used to describe the separate gas-bags of an airship of the rigid (or Zeppelin) type.

Balloon—Any form of envelope used to contain gas lighter than air, with which to lift anything from the ground.

Banking—The operation, generally effected by the ailerons, of turning an aeroplane on to its side when rounding a corner—as a cyclist "banks over" at a turn.

Biplane—A two-decker aeroplane. One with two pairs of wings, one above the other, on two planes.

Body—See "fuselage" and "nacelle."

Bonnet—The cowl covering the engine of an aeroplane.

Bracing—The wires or cables used to tension up and stay the various parts of an aeroplane together. Also used of the wires staying the nacelle of an airship.

CAPTIVE BALLOON—A balloon used as an observation post, and anchored to ground or ship.

Chassis—The landing gear, or undercarriage, of an aeroplane, including the wheels, axle, skids, chassis-struts, and their bracing wires.

Climb—To depress the tail of an aeroplane so as to point the nose upwards for an ascent.

Clinometer—An instrument used to show the degree of climb or dive.

Cockpit—The hole in the fuselage of a "tractor" in which the pilot and passenger sit.

Control-lever—The lever controlling the ailerons, or warp, and elevator of an aeroplane.

Controls—The whole mechanism, including lever or wheel, rudder-bar, ailerons, or warp, rudder, and elevator, and their connecting wires, which control an aeroplane in the air. Also used of airship controls.

DIRIGIBLE—Common phrase for an airship, which is in fact a dirigible (or directable) balloon.

Dive—To stand an aeroplane vertically, or nearly so, on its nose for a rapid descent.

Dope—The varnish, generally non-inflammable, used to render the fabric, or linen covering, of aeroplane wings and fuselages proof against weather, oil, and petrol, and to maintain it properly tensioned up and drum-like.

ELEVATOR—The flap or flaps behind the tail of an aeroplane, which control its vertical path by raising or depressing the tail. They are, in fact, as rudders placed horizontally.

FABRIC—The linen cloth with which the wings, fuselage or nacelle, and control surfaces of an aeroplane are covered.

Fin—A vertical surface fitted to increase the side area (or surface) of an aeroplane or airship.

Flap—A small flat movable surface used to control aircraft. See *Aileron* and *Elevator*.

Fuselage—The body, including the engine, tanks, pilot and passenger seats, etc., from the nose to the tail of a tractor-drawn aeroplane.

GLIDE—To descend at an aeroplane's natural speed by the force of gravity, with the engine stopped or so throttled down as not to exert any driving force. See *Vol-plané*.

Gondel or **Gondola**—The German word, frequently used in England, for the car or cars below an airship.

HALL—The German word for an airship shed. Sometimes used by those in this country concerned with airships.

Hangar—Literally a shed of any kind (in French), but used only seldom in this country to indicate specifically an aeroplane shed. Pronounced rather like "Ongar," in Essex.

Hydro-aeroplane—An aeroplane fitted with floats designed to alight on and get off water. See *Waterplane* and *Seaplane*. It is lifted out of the water by its wings, and need not necessarily "hydroplane" first.

Hydroplane—A motor-boat with a flat or flattish bottom, which skims along the surface of the water. Nothing at all to do with aircraft.

LOOP—To "loop the loop" in an aeroplane is to turn a back somersault in the air by forcing the tail down and the nose up, and keeping there till the machine "climbs" round a circle, or nearly so.

MONOPLANE—An aeroplane with a single pair of wings, both on one plane.

NACELLE—The body containing pilot, passenger, tanks and engine, etc., of a "pusher" machine. Also the car or gondola of an airship. Literally, in French, a "cradle."

PILOT—The person actually controlling an aeroplane or airship.

Plane—Strictly, a plane or flat surface. Commonly used to describe the wings of an aeroplane, which are, in fact, curved. "To plane" is frequently used to indicate the action of planing, or "gliding" down. See *Glide* and *Vol-plané*.

Propeller—An airscrew which pushes. Commonly used for "tractor" air-screws also.

Pusher—An aeroplane driven from behind the wings by a propeller or airscrew, which pushes.

RIBS—The light framework of the wings running across the spars to support the fabric covering.

Rudder—A movable vertical surface fixed above the tail, or partly above and partly below it, to steer the machine on a horizontal path, just as does the rudder of a boat.

SEAPLANE—The official name for any form of waterplane (hydro-aeroplane or aero-hydroplane) capable of operating at sea.

Side-slip—To "bank" too much so that an aeroplane falls down sideways owing to the force of gravity. In a well-designed machine this is followed by a "nose-dive," from which a machine can be easily recovered. Insufficient "bank" on a turn causes an outward side-slip, owing to centrifugal force.

Skid—The horizontal fore and aft bar or bars of a chassis, which slide along the ground like sleigh-runners.

Spar—The main beams of an aeroplane's wings, running from the butt of the wing where it joins the fuselage, out to the wing-tip.

Stall—To "climb" an aeroplane too rapidly, so that it loses speed and halts in the air, an operation often followed by a side-slip and nose-dive.

Struts—The vertical posts, of wood or steel tube, between the upper and lower planes of a biplane. Also the vertical or sloping posts in the chassis.

TAIL—A fixed horizontal aerofoil, or plane, either fitted at the rear of the fuselage of a "tractor" or carried on tail-booms behind the nacelle of a "pusher." It may carry part of the weight of the machine, or it may act merely as a damper to vertical oscillations.

Tractor—An aeroplane drawn by a tractor "air-screw," fitted in front of the wings.

Turnbuckle—The right-and-left screws used to tighten up bracing wires and cables.

VOL PIQUÉ—French for a dive, or "peaked flight."

Vol Plané—French for a glide, or "planing flight." Never used by bona-fide aviators or airmen. See *Glide*.

WARP—To pull down or lift up the rear edge of a wing-plane instead of using ailerons.

Waterplane—A useful generic term describing all forms of aeroplanes usable on and off water, including seaplanes and those only fit for calm waters.

Wing—A single "plane" or "aerofoil" of an aeroplane. A monoplane has two wings, one on each side; a biplane has two on each side.

ZEPPELIN—An airship with a rigid outer frame divided into numerous compartments, each containing a separate cheese-shaped gas-bag.

PRINTING

ACCENTS—Accented letters.
Ads.—Advertisements.
Apron—Flap of paper pasted on matrix.
Ascending Letters—Letters with heads extending above body, as b, d, f, h.
Autoplate—Machine for casting and finishing sterotype plates for newspaper presses.

BACK MARGIN—Inner edge of page.
Bastard Fount—Type with body out of proportion to face.
Bastard Title—Abbreviated title-page.
Beard—Space on body of type allowed for ascending and descending letters; also called shoulders.
Bearer—Type-high metal, used to modify impression.
Bed—Type-carriage.
Bevel—Sloped edge of stereotype plate or letter.
Blanket—Impression pad of wool, felt, or rubber.
Blocks—Mounted plates, or woodcuts.
Bodkin—An awl used in correcting.
Body—Shank of a letter; page without headlines, folios, or footnotes; book, without preface, title-page, &c.
Bourgeois—Size of type (9 points).
Boxes—Divisions of type-case.
Brace—Sign of inclusion, coupling.
Brass Rules—Slips of brass used for printing lines.
Break—End of a paragraph.
Brevier—Size of type (8 points).

CAP.—Capital letter.
Case—Shallow wooden tray divided into compartments for holding type.
Cast—Moulded metal, type or plate.
Cast—See Set-off.
Casting-box—Iron box, holding matrix, in which are cast stereotype plates.
Cast-off—Calculating length of MS.
Catch-line—Words at head of galley denoting contents.
Chase—Iron frame in which type is locked.
Clicker—Workman who distributes copy and makes up pages or columns.
Clump—Type-high metal, put round pages to be stereotyped.
Coffin—Type-carriage of press or machine.
Copy—Manuscript.
Cylinder—Horizontal roller on printing machine.

DESCENDING LETTERS—Letters with tails below the body, as g, p, q, y.
Dis.—Type ready for distributing back into case.
Dressing—Placing forme on machine, and preparing cylinder.

ELECTRO—Electrotype plate of page or picture.
Em-quad—Space the square of depth of type body.
En-quad—Half of em.

FACE—The letter on the type.
Feet—Bottom of type. "Off its feet," type raised or askew.
Flimsy—News copy that has been duplicated on flimsy (tissue) paper.
Footstick—Half-wedge put at bottom of type in chase, for lock up.
Fore-edge—Outer margin of page
Forme—Type locked in chase; specially applied to groups of pages.
Fount—Complete set of one style of type.
Frame—Wooden or iron structure holding type-cases, forming bench for cases in use.
Friar—A light mark on printed sheet.
Frisket—Paper-covered frame, with opening cut to size of type; folded on the tympan to protect the sheet.
Furniture—Metal or wooden blocks used in chase.
Flong—Substance of stereotype matrix.
Fudge-box—Device on press for printing late news into stop-press blank.

GALLEY—Tray for holding type when it is set.
Galley Press—Press for proofing type on galley.
Galley Proof—Slip printed from galley.
Gripper—Bar set on cylinder to take on sheets.
Gutter—Space between pages in forme.

HAIR SPACE—Thinnest of spaces, eight to the em.
Hand Roller—Ink roller of hand press.
Hot Plate—Steam-heated plate for drying stereo matrix.

IMPOSING STONE—Table on which set type is prepared for printing or stereotyping.
Imposing Schemes—Method of placing pages so that they will print in order.
Impression—Stamp of type on paper.
Impression Cylinder—Cylinder carrying and impressing the sheet on type.
Imprint—Name and address of printer.
Indent—Space shortening first line of paragraph.
Inferiors—Index figures or letters, smaller than type body, ranging with bottom of letters.
Inner Forme—Set of pages containing the second and second last pages of a sheet.
Italic—*Sloping type, like this.*
Inset—Supplementary matter.

JOB—Any work not a book or pamphlet.
Jobbing—Doing odd work; commercial printing; small jobs.
Justify—Spacing out the line; setting different sizes of type to each other.

KISS—Rollers coming into contact.
Knocking up—Making sheets lie evenly over each other.

LAY OF CASE—Arrangement of type in case.
Leads—Lead slips used for making spaces between lines.
Linotype—Machine for composing and casting solid line of type, or "slug."
Locking up—Wedging type in chase.
Long Primer—Size of type (10 points).
Lower-case—Small letters; the case used for the small letters.
Lye—A type-cleansing liquid, usually made of potash.

MS.—Author's copy.
Make Even—Finishing copy at end of line.
Make up—Putting type together into pages or size of job.
Making Ready—Preparing tympan or impression cylinder for printing.
Mangle—Machine for rolling flong into type to produce matrix.
Matrix—Mould of type or plate.
Measure—Length of line, expressed in ems of pica.
Minion—Size of type (7 points).
Modern—Plain Roman type.
Monk—Black spot on sheet, caused by inkstain or other dirt.
Monotype—Two machines (keyboard and caster), for composing and casting lines of separate types.

N.P.—New paragraph.
Nicks—Marks on front of type shank.
Nonpareil—Size of type (6 points)
Numbers, long and short—Large and small quantities.

O.S.—Old style. Modern imitation of antique type.
Octavo—Sheet folded into eight leaves.
Outer Forme—Forme containing first and last pages of a sheet.
Overlay—Sheet patched to produce good impression.
Overrun—Altering the measure of type to take in corrections, or to go round an illustration.

PACKING—Sheets of paper and blanket in tympan or on cylinder to graduate impression.
Perfect (to)—Print on both sides.
Pica—Size of movable type first used; standard of measurement (12 points).
Pie—Type thrown into disorder.
Planer—Flat block of wood for levelling down type.
Platen—Impression plate of hand press or machine.
Point—One-twelth of pica—1/72 in.
Process Blocks—Illustrations produced by a photographic process.

QUADS—Spaces larger than em.
Quarto—Sheet folded twice, giving four leaves.
Quoin—Wedge for locking type in chase.

READER—A corrector of proofs.
Register—Adjustment by which pages print exactly back to back, or one colour exactly on top of another.
Reglets—Wood slips for spacing bill lines.
Rollers—Ink distributors.
Roman—Common type, not italic.
Rotary—Type-cylinder machine.
Rough Proof—Rough impression of type pulled for correction.

SANSERIF—Form of type without fine strokes at terminations of lines. Like this: **SANSERIF.**
Screw-chase—Chase fitted with screws for locking up instead of wedges and quoins.
Serif—Fine lines at ends of letters.
Set-off—Smudging of sheet at second impression by impression cylinder or tympan fouled by ink from first printing.
Setting-rule—Slip of brass against which the compositor sets, shifting it line by line.
Setting-stick—Small hand tray with movable bar for holding type being set.
Shooter—Wedge for driving quoins.
Sidenotes—Notes on margin of page.
Sidestick—Half-wedge laid on side of page for locking up.
Signature—Printer's letter to mark number of a sheet—*i.e.*, in a book, etc.
Small-cap—Capitals same depth in face as lower case.
Slur—Defective impression.
Sorts—Special letters of a fount.
Space-band—Wedge device on linotype for justifying lines.
Spaces—Type without face for making space between words.
Stereotype—Metal cast of page secured from matrix.
Stick—*see* Setting-stick
Stop-press—Space for late news.
Superiors—Small index figures or letters, to range with top of letters.

TAKE—A share of copy.
Thick Space—Space, three to the em.
Thin Space—Space, five to the em.
Tweezers—Small pincers for picking out letters.
Tympan—Parchment-covered frame on hand press that carries the sheet on to type.

UNDERLAY—Sheet or patchings put under type or stereo-plates to regulate impression.
Upper-case—Capitals; the case used for capital and small-capital letters, figures, etc.

VIBRATOR ROLLERS—Rollers conveying ink from ductor to ink slab.

WAVER ROLLERS—Rollers set diagonally to distribute the ink.
Web Machine—Machine supplied with paper from a reel.
Wrong Fount—Letter of different character from the fount being used—marked w.f. on proof.

BIOLOGY

ABDOMEN—In vertebrates, the hinder part of the trunk, containing the principal organs of digestion and excretion.
Abiogenesis—Spontaneous generation, or the production of living beings without pre-existent life.
Accretion—The process by which inorganic bodies grow larger.
Acquired Characters—Characters acquired by the individual, as distinct from those bestowed by heredity.
Adaptation—The adjustment of animals or plants to surroundings.
Adolescence—The period between childhood and manhood or womanhood.
Ætiology—The science of the causes of diseases.
Albinism—Whiteness or paleness.
Albumen—The complex substance of which, *e.g.*, white of egg is composed.
Algæ—An order or division of the cryptogamic or acrogenous plants.
Allelomorphic Characters—Characters that are opposed (a Mendelian term).
Ambergris—A concretion formed in the intestine of the sperm-whale.
Amitotic—Simple cell-division, usually marked by the dumbbell-like construction of the nucleus.
Amœba—A unicellular animal which changes its shape.
Amœboid—Like an amœba, changing in form.
Amphibia—One of the five classes of vertebrates.
Amphimixis—The sexual mode of reproduction.
Anabiosis—The return to life after apparent death.
Anabolic—Creative or constructive.
Anabolism—The chemical processes which build up the tissues.
Analogous—Having the same function.
Anatomy—The study of structure.
Ancestral Inheritance—Sir Francis Galton's law of heredity which asserts that the factor of inheritance from the parents is one half, from the grandparents one quarter, and so on.
Animism—The attribution of life to natural phenomena, such as the thunder, the river, the avalanche, and so on.
Antenna—A feeler of an insect.
Anthropography—A description of man or of the human race; or of the distribution of our race in respect to situation, language, custom, etc.
Anthropoid—Resembling man.
Anthropology—The natural history or physiology of the human species.
Aorta—The great artery of the body.
Archebiosis—Another term for abiogenesis.
Asexual—Reproduction in which sexes are not concerned.
Atlas—The name of the first vertebra in the neck.
Atrophy—A wasting away of the body.
Auricle—One of the cavities of the heart.
Autogamy—Self-fertilisation.
Aves—The class of birds.
Axis—The second vertebra of the neck.

BILATERAL SYMMETRY—Having right and left sides alike.
Biochemistry—The science that studies the chemistry of life.
Biodynamics—The doctrine of vital forces or activity.
Biogenesis—The doctrine that all living matter has directly descended from pre-existing living matter.
Biogenetic Law—The recapitulation doctrine, the tendency for the individual to recapitulate stages in the history of the race.
Biology—The science of life and living things.
Biometrics—The application of mathematical methods to the statistical study of life.
Biotic Energy—The energy phenomena witnessed in living matter.
Biparous—Bringing forth two at a birth.
Biped—An animal having only two feet.
Blastophthoria—Germ-cell poisoning.
Blastula—A hollow ball of cells.
Blood—The fluid which circulates through the arteries and veins of animals.
Blood Relationship—Species that are related by nearness of blood constituents (anthropoid apes and man, for example).
Blubber—A thick layer of fat under the skin.
Body Cavity—The space within the body-wall.
Botany—The modern study of plants, a division of biology.
Brachial—Pertaining to the arms.
Branchial—Pertaining to the gills.
Bronchus—A branch of the windpipe.
Bud—An outgrowth which becomes an individual animal.
Budding—One of the methods of cell reproduction.

CALCAREOUS—Pertaining to lime.
Canine—Dog-like, applied to certain teeth.
Carnivorous—Flesh-eating.
Carpus—The wrist, the small bones between the forearm and the hand.
Cartilage—Gristle.
Caudal—Pertaining to the tail.
Cell—The unit of structure, a nucleated mass of protoplasm.
Centrosome—A minute body found within a cell.
Cephalic—Pertaining to the head.
Cerebellum—The small or hinder brain.
Cerebral Hemispheres—The highest part of the vertebrate brain.
Cervical—Pertaining to the neck.
Chemiotaxis—A property of attraction drawing, *e.g.*, micro-organisms or their products to the white corpuscles of the blood.
Chemotropism—The response to chemical stimulation.
Chlorophyll—Green colouring-matter of plants.
Chloroplasts—Organs embedded within the cytoplasm of the plant in which the process of photosynthesis takes place.
Choroid—The pigmented middle coat of the eye.
Chromatin—Colourable matter found in the nucleus of cells.
Chromosomes—The pieces into which the cromatin network of the dividing nucleus breaks up; colour bodies.
Cilia—Hair-like, minute filaments projecting from the surface.
Ciliary Action—The movement of cilia.
Clavicle—The collar-bone.
Climacteric—The change of life. The menopause.
Cloaca—The cavity into which the excretory organs open, as in a frog.
Cnidoblasts—Stinging cells.
Commensalism—The association of two organisms to the advantage of one or both.
Conifers—Cone-bearing plants.
Conjugation—The fusion of two individuals for reproductive purposes.
Continuity of the Germ Plasm—August Weismann's theory of heredity; the persistence of specialised cells throughout consecutive generations for the production of new life.
Convergence—The tendency for organs and species to resemble each other.
Corpuscle—Small cells or particles.
Cosmozoa—The idea that life has existed in the Universe from eternity, and has simply been transferred from one world to another.
Crop—A part of the gullet for temporary food-storing.
Cross-fertilisation—Fertilisation of an egg by a sperm from another organism.
Cross-pollination—Transferring pollen from the stamen of one flower to the stigma of another.
Crustacea—One of the classes of articulated animals.
Cyclops—Possessing a single eye, a family of very minute crustacea.
Cytode—A simple portion of protoplasm without a nucleus.
Cytology—The study of cells.
Cytoplasm—Protoplasmic matter of a cell.

DARWINISM—The doctrine of the origin of species by natural selection.
Death—Cessation of the activities of life.
Degeneration—The process by which organisms become parasites or fixed.
Development—A series of changes in the early life of an animal during which it passes from the state of a single fertilised cell to the adult condition.
Digitigrade—Walking upon the digits.
Digits—The fingers.
Distal—The end of a limb or extremity farthest from the trunk.
Dorsal—Pertaining to the region of the back.
Dysgenic—Anti-eugenic.

ECTODERM—Outer cellular layer of the organism.
Élan Vital—Professor Bergson's phrase for the push, thrust, will, or force that underlies all life, the vital urge.
Embryo—The young animal during development within the egg or womb.
Embryology—Science of development.
Endoderm—The inner cellular layer of an organism.
Endoskeleton—Internal hard supporting structures, as bones.
Entoderm—A layer of cells round the yolk sac.
Environment—The surroundings.
Epiblast—The outer layer of cells of the blastula.
Epigenesis—Gradual development from the simple to the complex.
Eugenics—The science of good begetting; race culture.
Evolution—The unfolding of successive phases of development in the growth of animal and vegetable organisms.
Excretion—The throwing off of waste products from the system.
Exogamy—The custom of marrying outside one's own clan.
Exoskeleton—External hard supporting structures.

FACTOR—The representatives, in the germ plasm, of the characters of the organism. A Mendelian term.
Femur—The thigh-bone.
Ferments—Special substances having the property of facilitating and hastening chemical actions.
Fertilisation—The fusion of two germ-cells.
Fission—Reproduction by splitting of the parent cell.
Flagella—Long, whip-like outgrowths of a cell.
Fossils—The remains of organisms or their traces in rock.
Fungi—In botany, a large natural order of cellular and flowerless plants.

GAMETE—An unfertilised germ-cell.
Gemmation—Reproduction by budding.
Genesis—Herbert Spencer's term for the proportion of energy expended upon the race. See *Individuation*.
Genetics—The modern scientific study of heredity.
Genus—A group including one or more species.

Gill—An organ for breathing the air contained in water.
Gizzard—A part of the digestive tube in which food is broken up.
Gland—A soft, secreting organ of the body.

HÆMOGLOBIN—The colouring-matter of the blood.
Herbivorous—Feeding on plants.
Heredity—The relation between parents and offspring in respect to certain characters.
Hermaphrodite—Having the two sexes united in one individual.
Heterozygotes—Hybrids derived from mixed zygotes.
Hibernation—Passing into a torpid winter condition, as in reptiles.
Histology—Science of minute structure.
Homogamy—The mating of like with like.
Homologous—Having a similar organ; constructed on a similar plan.
Homozygote—True breeding individuals containing only one kind of gamete.
Hormones—Chemical substances formed in epithelium which excite the secretion of glands.
Host—The organism that carries a parasite.
Hybrid—An individual produced by crossing two species.
Hypoblast—The inner layer of the blastula.

IMAGO—The adult stage of insects.
Incisor—The front tooth in mammals.
Individuation—Herbert Spencer's word for the proportion of energy expended upon the individual.
Instinct—A natural impulse, impelling organisms to do that is necessary for existence.
Intussusception—The continual absorption of new material from without, and its transformation in the substance of the body.
Invertebrate—Without a backbone.
Irritability—The property by which an organism responds to stimulation.

KARYOKINESIS—Complex cell-division, involving a division of the chromatin of the mother-cells between the daughter-cells.
Katabolic—Disruptive, the contrary to anabolic in vital metabolism.

LABIUM—A lip.
Labrum—The upper lip.
Larva—A young animal which has left the egg and is free, but incompletely developed.
Life—The state or condition of a being which grows and which reproduces itself.

MACRONUCLEUS—The large nucleus in some organisms.
Mammals—A class of Vertebrates that suckle their young.
Maturation—The process of chromatin reduction in the nucleus in preparation for fertilisation.
Melanism—Unusual darkness of colour.
Mendelism—The science that studies heredity along the lines laid down by Gregor Mendel in 1865.
Mesoderm—The middle cellular layer of organisms.
Metabolism—Chemical changes in the body.
Metamorphosis—The period in the life of some insects during which the change occurs from the larva to the imago.
Metazoa—Many-celled animals.
Micronucleus—The small nucleus in some organisms.
Mimicry—Resemblances between species, often for protection.
Miocene—A term applied to the middle division of the tertiary strata.
Mitosis—See *Karyokinesis*.
Monogamy—The marriage of one wife only.
Monotremes—The lowest mammals.
Morphology—Science of structure.
Morula—A solid ball of cells.
Mutations—Differences in species due to changes in the inheritance—to the alteration in the germinal constitution.

NATURAL SELECTION—The survival of individuals which possess advantageous variations.
Necrobiosis—The gradual transition between life and death.
Neural—Pertaining to the nervous system.
Notochord—A supporting rod under the central nervous system in all vertebrate embryos, usually replaced later by the backbone.
Nucleus—The specialised portion of protoplasm within a cell.

OCCIPITAL—Pertaining to the back of the head.
Omnivorous—Having a mixed diet.
Ontogeny—Individual development.
Organic Evolution—The evolution from the primal and simple forms of life to the complex and highly specialised forms of today.
Osseous—Bony.
Ovary—The female sexual gland.
Oviduct—The tube from the ovary to the exterior.
Oviparous—Producing eggs, or producing young from eggs.
Ovoviviparous—Producing young from eggs hatched within the body.
Ovum—The female sexual cell, the egg.

PANGENESIS—Charles Darwin's theory of heredity to explain the Lamarckian doctrine of the inheritance of acquired characters.
Panspermia—See *Cosmozoa*.
Parasite—An organism which lives on or in another.
Parthenogenesis—Production of new individuals from unfertilised eggs, and therefore without the male gamete.
Pentadactyle—Having five digits.
Permanent Dentition—The second set of mammalian teeth.
Photosynthesis—The manufacture by the green plant, in the presence of sunlight, of its own organic compounds.
Phylogeny—The evolutionary history of animals.
Phylum—A large division of the animal kingdom—*e.g.*, Vertebrates.
Physiology—The science which describes and endeavours to explain the phenomena manifested by living beings.
Pia Mater—A thin membrane which encloses the lobes of the brain.
Plantigrade—Walking upon the palms of the hands or soles of the feet.
Pleistocene—The Glacial or Ice Age.
Pliocene—The name given to the topmost division of the Tertiary system in geology.
Polygamy—Plurality of wives at the same time.
Protoplasm—Physical basis of organised tissues; simplest form of living matter.
Primates—The highest apes and man.
Protozoa—Lowest division of the animal kingdom: one-celled animals.
Pseudopodia—Processes pushed out by unicellular organisms for the purposes of locomotion.
Psychology—The study of behaviour.
Pupa—A stage in insect life.
Pure-lines—A line including all the descendants of a single individual, belonging to a race which is reproduced exclusively by self-fertilisation.

RACIAL POISONS.—Those poisons which, while injurious to individuals as individuals, also injure future generations by poisoning the germ-plasm.
Regeneration—The process of repair after injury.
Regression Towards Mediocrity—A law asserted by Sir Francis Galton that the offspring of those who are above or below the mean of a race tend to return toward that mean.
Reptiles—One of the division of Vertebrata.
Reversed Selection—The selection of the worst types for the purpose of parenthood.
Reversion—The appearance of traits like those of remote ancestors.

SECONDARY SEXUAL CHARACTERS—The differences between the two sexes, other than that of the reproductive organs.
Segmentation—Early divisions of an egg after fertilisation; also the division of an individual into rings or segments.
Self-fertilisation—Fertilisation of an egg by a sperm from the same individual.
Self-pollination—Transference of pollen from stamen to stigma of the same flower.
Sex—The essential difference between male and female.
Sexual Selection—A special kind of natural selection taking place within the limits of an interbreeding set of animals or "species."
Sociology—The science that studies society.
Soma—The body, as distinct from the germ-cells.
Somatic—Pertaining to the body as opposed to the germ-cells.
Special Creation—The belief that species were created independently.
Spermatozoon—The male sexual cell.
Spinal Cord—The spinal part of the central nervous system.
Sterility—The inability to reproduce offspring.
Stigma—An air-tube in insects. The pollen-receiving organ in plants.
Stirpiculture—Sir Francis Galton's original name for eugenics, the cultivation of "stirps" or stocks.
Stomata—Openings in plants for the supply of carbon dioxide, situated in the epidermis of the leaves.
Synthesis—Building up, creating, adding together.

TELEGONY—The supposed influence on the progeny of a female of a sire with which she had been previously mated.

UNGULATES—The hoofed mammals.
Unicellular—Organisms having only one cell.

VACUOLE—A space in the protoplasm of a cell.
Variation—The appearance of new traits.
Vegetative Propagation—Reproduction by other methods than egg production—*e.g.*, budding or fission.
Ventral—Pertaining to the lower aspect of the body.
Vertebrata—Backboned animals.
Vestigial—Pertaining to an organ which has undergone reduction.
Viscera—Organs within a body cavity.
Visceral Clefts—The slit-like openings on each side of the throat which every vertebrate embryo exhibits.
Viviparous—Producing young alive.

WARNING COLOURATION—Conspicuous colouration of organisms which have dangerous or unpleasant traits.

ZOOGEOGRAPHY—The distribution of animals on the earth.
Zoology—The science of animals.
Zygote—A fertilised germ-cell.

BUSINESS

FOR TERMS NOT GIVEN HERE, SEE THE INDEX

A.a.r. or a.r.—Against all risks.
Abandonment—In marine insurance, a notice of surrender of insured property to the underwriters, prior to a claim on them for total loss.
Abatement—An allowance made in an account, or in respect of goods.
Above Par—When the price of stocks and shares is above their face value.
Abstract Ledger—A book in which is recorded the cost of the labour and each material supplied for a contract.
A/c—Account.
A/C—Account current.
Acceptance—The signing of a bill of exchange, whereby the acceptor or person signing makes himself responsible for payment. See Index.
Acceptances—Bills accepted by a bank or firm, and reckoned among the liabilities of the acceptors to the payee.
Acceptance supra Protest—Where a bill has been protested, and is accepted by another person to prevent the bill being dishonoured and the drawer's credit impaired.
Accepted Bill—A bill of exchange after the drawee has written *Accepted* across it, with his name and the date.
Accommodation Bill—A bill drawn by one person and accepted by another for the convenience of the first, though no consideration has been given for it. The drawer promises to pay the bill when it falls due. Also called Wind Bills and Kites.
Account Current—A copy in Dr. and Cr. form of a person's account, as shown in another's ledger.
Account Sales—An account showing particulars of sales effected and expenses incurred by an agent on behalf of a principal.
Acquittance—A written discharge in full of some debt or liability.
Active Bonds—Bonds bearing a fixed rate of interest, and payable in full from the date of issue.
Active Circulation—Notes of a bank actually in the hands of the public.
Act of Bankruptcy—An act by which a debtor becomes liable to be adjudicated a bankrupt.
Act of God—Perils beyond human control, such as those resulting from wind, weather, lightning, etc.
a/d—Ante-date. To date a document before the true time.
A/d—After date.
A/D—Alternate days (advertising).
Ad interim—Lat. In the meanwhile.
Adjudication Order—An order of the Court declaring a debtor bankrupt.
Adjustment—Settlement of a claim, particularly of an insurance claim.
Ad referendum—Latin. To be further considered.
Ad val.—Short for Ad valorem.
Ad valorem—Latin. According to value and not quantity. Used of Customs duties. Also written A/V.
Advance Note—A draft on the owners of a ship for a month's wages, given by the captain to the seamen, and payable after the vessel sails.
Advice—Notification regarding mercantile transactions, especially despatch of goods.
Advice Note—A note sent by a railway company stating that certain goods are at one of their stations, and asking for instructions.
Affidavit—A sworn written declaration.
After date—Used in bills of exchange, meaning after the date of the bill.
After Sight—This term in a bill of exchange means that it must be seen by the drawee, and the date of his acceptance inserted.
a.g.b.—A good brand.
Agenda—Memoranda of business to be done. See page 2987.
Agent—One authorised to represent another or to buy or sell for him. See Commission Agents.
Agio—Difference in value between various kinds of money of the same country and denomination. Also difference between real and nominal value of money.
Allocate—To allot.
Allonge—A slip of paper attached to a bill of exchange to provide room for further indorsements when the back of the bill is covered.
Allotment Note—A draft drawn by seamen on the owners of a ship for the monthly payment, while they are away, of a portion of their wages to those dependent on them.
All Round Price—A price which includes all extras.
Amortisement—The redemption of bonds or shares by periodical drawings from a sinking fund.
Anchorage—Dues paid by a berthed ship for the use of quays,
Annuity, Deferred—An annuity beginning after the expiration of a certain period.
A/o—Account of.
Appraiser—A person licensed to value property.
Arbitration of Exchange—A comparison of the direct rate of exchange for remittance between two countries with that obtained by remitting through intermediate places, to see which is more advantageous. When through one intermediate place, it is simple arbitration; when through more, compound arbitration.
Articles of Association—A deed of the internal regulations of an incorporated company by which the management of the business is governed.
A/S—Account sales.
As per advice—A term on a bill of exchange, meaning that the drawer has given notice to the drawee that the bill has been drawn on him.
Assignment—The transfer of property or rights to another, called the assignee. Also the document of transfer.
"A" Stock—See Deferred Stock.
At sight—A term used on bills of exchange that are payable on demand and do not require accepting.
Audit—An examination, by qualified auditors, of books, accounts, etc., to see that they are in order and that no fraud or mistake has been made.
A/V—Ad valorem.
a/v—A vista. At sight.
Av. or Average—A term in marine insurance, meaning a contribution upon all parties concerned to meet the losses. *Particular average* is the contributions to which the underwriters are liable for the partial loss of property by any of the accidents against which insurance has been made. *General average* is a contribution made by the owners of the ship, freight, and cargo to cover the value of any property thrown overboard or destroyed to save the rest. The proportion to be borne by each of the insured interests is drawn out by an average adjuster or stater.
Average Bond—A document made out by the captain of a ship that has incurred a general average loss, and signed by the consignees of the cargo before the goods are delivered to them. Both parties are thus held liable for their proportion of the loss.
Average Clause—A clause in a marine insurance policy, stating that certain articles shall be free from average unless general, and that others shall be free from average if less than a certain percentage named.
Averaging—Buying more stock or goods at a lower price than a previous purchase, in order to reduce the average cost.

B/—Bale or bag.
Back—See Backwardation.
Backed Note.—A receiving note with a shipbroker's endorsement authorising goods to be barged alongside the ship.
Backwardation—The rate paid by speculative sellers of stock for being allowed to carry over from one fortnightly account to another instead of selling.
Bailment—The delivery of goods to a person for a particular purpose.
Bank Bills—Bills of exchange issued by a bank.
Bank Post Bills—Bills of exchange issued by the Bank of England, payable to order seven days or sixty days after sight.
Bank of Deposit—A bank which receives money on deposit at an agreed rate of interest.
Banks of Issue—Banks which issue their own notes.
Barratry—Fraud or criminal conduct of the master or mariners of a ship, whereby the owners or the insurers of the ship or cargo are cheated.
Barter—Exchanging of goods for goods.
Basis Price—A price that does not include the extras charged in trade for quality, size, etc.
Bd.—Bond or bound.
b/d—Brought down (bookkeeping).
B/E—Bill of exchange.
Bear—A speculator who sells for future delivery stocks or shares he does not at present possess, hoping to buy them in the meantime at a lower rate.
Bearer Cheque—See Cheque to Bearer.
Bearer Securities—Any security, such as stocks, bonds, etc., which may pass from hand to hand. Bearer securities are not enrolled on any list, and are therefore proof of ownership.
Bear Squeeze—See Corner.
B/F or B/f—Brought forward.
Below Par—When the price of stocks and shares is less than their face value.
Bill of Entry—A statement to the Customs officials, in prescribed form, giving particulars of goods imported or shipped.
Bill of Health—A certificate given by the Customs to the captain of a ship as it leaves port, describing the state of health then prevalent at the port.
Bill of Sale—A contract making an absolute or conditional transfer of title to goods as security for debt
Bill of Sight—A provisional form of Customs declaration by an importer when ignorant of the exact nature or quantity of the goods landed. Later he makes a correct Bill of Entry.
Bill of Store—A Customs licence allowing a vessel to carry free of duty such dutiable provisions and stores as are needed for the voyage.
Bill of Sufferance—An authorisation by the Customs authorities giving permission to coasting traders to carry dutiable articles from one port to another, the goods being landed on sufferance wharves.
Bill Payable—A bill of exchange or promissory note the amount of which is payable by giver at a future date named therein.
Bill Receivable—A name given by the holder to bill of exchange due to him.
Bimetallism—A money currency based on a double standard of value—one of gold and one of silver.
Bl—Bale.
B/L—Bill of lading.
Blending—See Bulking.

Blockade—A bill of lading term meaning that a port is so surrounded by the enemy that no ship can enter.

B/o or b/o—Brought over (bookkeeping).

B.O.—Buyers' option.

Boarding Stations—Places where ships bring to, so that the Customs officers may board them for examination.

Bond—A document by which a person or company agrees to pay a certain sum at a stated time or in certain circumstances.

Bond, In—Goods liable to pay duty may be stored in a Government or licensed warehouse, and the duty remain unpaid till the goods are wanted. Such stored goods are said to be "in bond." The importer signs a "bond note" that he will pay duty when he clears the goods.

Bonded Carman—A carman licensed by the Customs authorities to handle and convey dutiable goods.

Bonded Warehouse—A warehouse sanctioned by the Board of Customs for the deposit of goods in bond.

Book Debts—Unpaid debts owing to a trader as shown by his books. They may be good, doubtful, or bad.

Bottomry—The making of a contract, set forth in a bottomry bond, whereby a ship and its tackle are mortgaged by its captain or owners to obtain money for special purposes, such as repairs. See also Respondentia.

Bought Note—A written contract sent by a broker to his principal, giving details of goods bought on commission.

Bounty—A premium paid to exporters by the Government to encourage a particular industry.

Bourse—A Continental Stock Exchange.

B/P.—Bills Payable or Bill of Parcels.

B.P.B.—Bank Post Bill.

B/R.—Bills receivable.

Breaking Bulk—Unloading any part of a ship's cargo after her arrival in port.

Broker—A middleman between buyers and sellers.

Brokerage—Remuneration to a broker.

Broker's Note or **Broker's Order**—Same as Backed Note, which see.

B/s.—Bales or bags.

B/S.—Bill of sale.

"B" Stock—See Preferred Stock.

Bt.—Bought.

Bucket Shop—The office of an outside stockbroker—that is, one who does not belong to the Stock Exchange.

Bulk—The total amount of goods stowed in a ship's hold.

Bulking—The operation of putting the whole of a parcel of tea, or coffee, or cocoa, etc., together into one bulk, and, after mixing, replacing in the packages.

Bull—A speculator who buys stocks, hoping to sell at a high rate before the time of settlement arrives.

Bullion Operations—The import and export of gold to create funds for exchange operations.

Buoy Dues—Dues payable by ships entering a port near which buoys are placed to guide and warn vessels.

Burden—The number of tons a ship will carry.

Bureau de Change—A commercial house or bank where foreign money is dealt in and exchanged.

Buyer's Option to Double—See Call of More.

Buyers Over—A market term meaning there are more buyers than sellers.

Buying In—When a seller has not delivered his securities to the buyer on the date arranged, the buyer can buy in against the seller, who is liable for all expenses in getting delivery.

Buying on Commission.—Buying for a principal, and charging a commission.

C/—Currency or coupon.

C/—Case.

C/A—Capital account.

Cable Transfer—See Telegraphic Transfer.

Call—A demand for money in payment of an instalment due on shares in a public company; also Stock Exchange term for an option to buy.

Call Letter—The notice making a call.

Called Bond—A bond called in for payment on a specified date, after which it no longer bears interest.

Call Money—Money lent at interest by bankers to billbrokers against security for repayment at a moment's notice.

Call of More—Stock Exchange term for the right of a buyer to "call for"—that is, buy on an agreed future date an equal quantity of stock to that first purchased. Elsewhere it is called "Buyer's Option to Double."

Cambist—One who exchanges foreign money, or deals in foreign notes, etc.

Capel Court—The Stock Exchange.

Capital Account—The account of the capital stock of a company. On one side are shown the subscriptions of shareholders; and on the other charges against capital.

Capitalise—To convert wealth or property into capital, so that it may be used for trading, etc.

Captain's Copy—An unstamped copy of a bill of lading for use of captain.

Captain's Draft—A draft by the captain of a ship on her owners or the brokers, for charge due by the ship.

Captain's Entry—A provisional entry by the captain when the merchant has failed to make the prime entry within the required time.

Cargo—The whole of the merchandise carried on a ship.

Cargo Book—A book kept by shipbrokers with details of all the merchandise shipped on their vessels, with weights, marks, etc.

Carriage Forward—The carriage to be paid by the receiver.

Carrying Over—A term used on the Stock Exchange for postponing the settlement of an account from one settling day to another.

Cartage—Same as Carriage.

Cartage Note—An account for cartage.

Cart Note—A note sent by the Customs authorities with locked vans when dutiable goods are moved from one place to another for warehousing or shipment.

Case of Need—A term used in an endorsement on a bill of exchange, thus: "In case of need, apply to Messrs. Brown & Jones." It means that the party named guarantees payment for the honour of the drawer should the bill not be met when due.

Cash—Ready money—coin, banknotes; also drafts, bonds, and other readily negotiable instruments.

Cash Articles—In banking, bills and cheques sent out for collection.

Casting—Adding up figures.

C.B.—Cash book.

c/d—Carried down. (Bookkeeping.)

Central Institution—Bank of England.

Certificate of Damage—A document issued by a dock company when imported goods are landed damaged.

Certificate of Incorporation—A certificate given by the Registrar of Joint Stock Companies, after all the registration requirements have been fulfilled, declaring that the company is duly registered and is incorporated under the Companies Act.

Certificate of Origin—A certificate signed by the exporter or his agent declaring the country of origin of the goods shipped.

Certificate of Registry—See Ship's Certificate of Registry.

Certificated Bankrupt—One who has a certificate from the Bankruptcy Court freeing him from his liabilities.

Certified Transfers—A transfer deed bearing an endorsement by the secretary or registrar of a company to the effect that share certificates to meet the transfer have been lodged at the company's office.

Cessio Bonorum—In Scotland the giving up by an insolvent debtor to his creditors of the whole of his property.

C.F.—Carried forward.

c.f.—Cost and freight.

c.f. and i.—Same as c.i.f.

Cgo.—Contango.

C.H.—Custom House.

Chamber of Commerce—A local association of commercial men formed to regulate and protect trade interests.

'Change—Short for Exchange. Going on 'Change means attending the market.

Charges Forward—A term used when carriage and other charges are to be paid by a buyer on receiving goods.

Charter—To charter a ship is to hire her.

Charter—A grant from the Crown conferring special privileges on a company upon the fulfilment of certain specified conditions.

Chartered Accountant—A person who holds the certificate of the Institute of Chartered Accountants.

Chartered Bank—A bank trading under a special charter from the Crown.

Chartered Company—A company authorised to trade by Royal charter or by special Act of Parliament.

Charter-party—An agreement whereby a ship or part thereof is hired for a certain time or number of voyages.

Charters—Short for Charter-party.

Cheap Money—A term used when the demand for money is small and the supply large, the current rates for discount being consequently low.

Cheque to Bearer—A cheque that does not need endorsing.

Cheque to Order—A cheque that must be endorsed with the payee's signature.

Cie.—Abbreviated form of French *compagnie*, company.

c.i.f.—Cost, insurance, and freight. Pronounced as a word Cif, with the C as in city.

c.i.f.c. & i.—Cost, insurance, freight, commission, and interest.

Cipher Code—A code of figures, each figure or group of figures representing a phrase or sentence.

Circular Note—A letter of credit on foreign firms, issued to a traveller by a banker, so that the traveller does not have to carry large sums in coin or notes. Also called Circular Letter of Credit.

Circulation of a Bank—The amount of notes payable to bearer which a Bank of Issue is allowed to circulate.

Clean—The term used in describing a mate's or wharfinger's receipt, or a bill of lading, when it bears no detrimental clause, such as "Cases Broken." When bearing such clauses the document is "Dirty" or "Foul."

Clean Bill—See Bill of Health.

Clear Days—Days exclusive of those on which a transaction is begun or ended.

Clearance—See Ship's Clearance.

Clearers—Bank clerks who attend the Bankers' Clearing House.

Clearing Ships—Fulfilling all the Customs formalities on the arrival or departure of a vessel. Ships arriving are "cleared inwards," and ships departing are "cleared outwards."

Cloff—An allowance for the weight of the wrapper in bale goods.

Closing Prices—The quotations for stocks and shares, according to the day's last sales.

c/m—Call of more.

C N—Credit Note.
c/o—Care of; carried over (bookkeeping).
C/O—Cash order.
Cocket—A Custom House warrant issued on the entry of goods for export, indicating that they have paid the duty.
C.O.D.—Cash on delivery.
Collateral Security.—A secondary security in addition to that already given.
Com.—Commission.
Commercial Bills—Bills of exchange.
Commission Agents—Agents who undertake buying and selling for others, receiving as remuneration an agreed commission. They usually sell in their own name, and have the goods they sell in their possession. Also called Factors.
Committee of Directors—A small body elected for a special purpose from their own number by a board of directors.
Company Promoter—One who organises and brings out a public company, paying the preliminary expenses.
Composition—Part payment by agreement of a bankrupt or insolvent in settlement of his debts.
Compound Options—See Call of More, Put and Call, Put of More.
Compounding—Making an agreement with creditors for a composition in return for a full discharge of indebtedness.
Compte rendu—French. Account rendered.
Confirmation Note—A slip usually attached by perforations to an order or contract, which the party can sign, detach, and post to the sender as confirmation of the receipt of the order.
Consideration—The reason demanded in law for the passing of any property from one person to another.
Consideration Money — The amount named in a transfer of stock as paid to the ultimate vendor. It often differs from the amount paid to the original seller, as his buyer may make a subsequent sale.
Consignment Note—A printed form requesting a railway company to receive and forward a consignment of goods.
Consolidated—A term used in describing funds which have been consolidated into one common debt.
Consols—Short for Consolidated Funds. Government securities of Great Britain, comprising a large part of the National Debt.
Consul—An officer appointed by the Government of a State to protect its commercial interests in a foreign country.
Consulage—The fees paid to a consul for his seal and signature to a document.
Consular Invoice—An invoice certified or visèd by the consul of the country to which the goods are going.
Contango—The additional rate of interest charged for carrying over a "bull" transaction till the next settlement day.
Contango Day—See Settlement.
Continuation—Carrying over transactions from one settling day to another.
Contra—A bookkeeping term meaning on the opposite side. In a cash-book, contra is the credit side.
Contract—A binding agreement between two or more persons.
Contract Note—A document setting forth the terms and conditions of a purchase or sale.
Convertible Paper Currency—Paper money which can be exchanged, on demand, at the Government bank, for coins to their face value.
Convertible Securities—Securities that can be easily converted into money.
Cooperage—Money charged by a dock company for mending, opening, or closing barrels.
Cordage—A term for all kinds of rope, cord, ships' rigging, etc.
Corner—To buy up securities or goods in such a quantity as to control the market. Also called Bear Squeeze and Rig.
Cost and Freight—Prices quoted C and F include cost and the charges for freight, etc., but the buyer must arrange and pay for the marine insurance.
Cost, Freight, and Insurance—Prices quoted C.F.I. or C.I.F. include the cost of goods, and all freight and marine insurance charges.
Counterfoil—The part of a document permanently kept in a book after the other part has been torn out. The counterfoil has duplicate particulars written upon it.
Country Notes—Banknotes issued by any Bank of Issue other than the Bank of England.
Coupon—A note or warrant for interest or dividend attached to transferable bonds for the purpose of being detached and presented for payment when such interest or dividend falls due.
Coupon Sheet—A connected series of coupons, which may be separated and presented for payment as they fall due.
Course of Exchange—See Rate of Exchange.
Cover—Cash or securities held by a broker to cover the risk of loss in transactions on behalf of a client.
Covering Note—A form issued by marine insurance companies as an interim policy while the formal policy is being prepared. Lloyd's underwriters call it a "slip.
C.P.—Carriage paid.
C P—Charter party.
Cr.—Credit or creditor.
Cranage—The charge for the use of a crane in loading or unloading a ship.
Credit Note.—A form similar to an invoice, but usually printed in red, showing the amount credited to a buyer for goods returned damaged, or for some similar allowance.
Credit Slip—Same as Paying-in-Slip.
Cross Exchange—An exchange made in London between two foreign places direct, as between Paris and Petrograd.
c/s—Cases.
Cum Dividend—With the dividend. A term used when the buyer of stocks or shares takes the dividend about to be paid. Also written Cum Div. See Ex. Div.
Cum. Pref.—Cumulative Preference.
Current—The present time; so that a price current is a price obtaining at the time it is quoted.
Customs Declaration—A form to be filled up when goods are sent out of the country, declaring their nature, value, and weight.
Customs Duties—Taxes levied upon the importation or exportation of merchandise.
Customs Entry—A form with full particulars of goods to be landed or shipped, which is given to the Customs officials.
Cutting—The lowering of prices beyond what is required by ordinary competition.
C.W.O.—Cash with order.

D/A—Deposit account (banking); discharge afloat (chartering).
D/a—Days after acceptance.
Dandy Note—An order from the Custom House to the warehouse officer requesting him to deliver to the searcher certain bonded goods required for exportation or ship's stores. See Pricking Note.
Dating Forward—Dating an invoice later than the time when the goods are delivered.
Days of Grace—The number of days which expire after the day stated in a bill of exchange as that on which payment is due, before such payment can be legally demanded. In the United Kingdom three days are allowed, except for bills payable on demand or at sight.
Days' Sight—Days counting after a bill of exchange has been accepted.
Day to Day Loan, Day to Day Money—Money borrowed from day to day against security at a fixed rate of interest.
D.B. Day-book.
Dbk.—Drawback.
D/C—Deviation clause.
D/D—Demand draft; days after date.
D/d—Delivered.
d/d—Days' date.
Dead Account—In bookkeeping, a term used for impersonal accounts, such as petty cash, goods account, etc. In banking, securities standing to the credit of a deceased person.
Dead Freight—When a shipper is unable for any reason to ship goods for which he has engaged room in a vessel, the owners can charge him for the freight such goods would have incurred, and this is called dead freight.
Dead Loans—Loans not paid at the time agreed, or for which no specified time is named.
Dead Security—Properties, such as collieries, mills, etc., which are worth nothing as security unless worked.
Dead Weight—Heavy goods which pay freight according to weight, and are usually placed in the bottom of a vessel to steady her.
Dead Work—Any unproductive work, such as erecting works, pumping water from a mine, which must be done before a profit can be made.
Dear Money—See Cheap Money.
Deb.—Debenture. See page 2985
Debit—To charge a person with some expense incurred on his behalf; to make an entry on the Dr. side of an account.
Debit Note—A form used when anyone debits another for goods returned, or for any charge made on them.
Debt of Honour—A debt for which there is no written proof.
Dec.—Decrease.
Declaration of Association—A form of words at the end of a memorandum of association in which certain persons declare their desire to be formed into a company, and agree to take shares.
Deed—A written contract which has afterwards been sealed and delivered.
Deed of Arrangement—An arrangement made by deed by an insolvent debtor for the benefit of his creditors.
Deed of Assignment—A deed made by an insolvent debtor giving up for the benefit of his creditors the whole of his property for realisation.
Deed of Inspectorship—A deed made by an insolvent trader handing his business over to creditors, who appoint trustees called inspectors to carry on or wind up.
De facto—Actually.
Def.—Deferred.
Deferred Bonds—Bonds bearing a gradually increasing interest until this reaches a fixed specified rate.
Deferred Stock—Also called "A" stock. Part of the ordinary stock of a railway that is not entitled to dividend until a fixed rate has been paid on preferred or "B" stock.
Deficiency—An allowance made by the Customs for loss on wines and spirits. If the loss is natural, as by absorption, evaporation, etc., the allowance is "Ordinary"; if through defective staves, worm-holes, slack hoops, or some such cause, it is "Special."

De jure—By right.

Del Credere—An engagement entered into by an agent, guaranteeing that all goods which he sells shall be paid for. For this he gets an extra commission, known as a Del Credere commission.

Delivery Order—A document, which must bear a penny stamp, sent by the owner of goods lying in a wharf or warehouse, requesting the person in charge to deliver the whole or part of them to the bearer.

Demand Draft—A draft payable on demand.

Demurrage—A charge per day made by the owner of a vessel as compensation for its detention beyond a specified time. Railway companies make a similar charge for the detention of trucks.

Dependencies—Assets likely to accrue, but the amount of which cannot be determined in advance.

Depreciation—A term used in bookkeeping when an allowance is made for wear and tear of machinery, tools, buildings, etc. This is usually fixed by a percentage of annual shrinkage in value, and is written off periodically.

Despatch Note—A document filled in and handed to the Post Office when a parcel is sent abroad by post.

Deviation—A marine insurance term for a departure from the terms of a policy which discharges the underwriter's risk.

Dies Non—A day on which for some reason business cannot be conducted.

Differences—The amounts paid by or to a speculator who does not take up the stock he buys. The differences are those between the buying and selling prices.

Direct Exchange—An operation of exchange between two countries based on their own rate of exchange, without the interposition of a third country.

Dirty Receipt—See Clean.

Dis.—Discount.

Discharge—To discharge a bill is to pay it.

Discharged Bankrupt—One who has received his certificate of discharge from the Bankruptcy Court.

Dishonouring a Bill—A drawee refusing to accept a bill, or an acceptor failing to pay it when due.

Dispatch Money—An allowance of so much per day or hour made by the owners of a chartered vessel when she is loaded or unloaded in less time than that specified on the charter-party.

Div.—Dividend.

Dividend—(a) Payment of a share of the profits to the shareholders of a limited company; (b) a payment of interest on the National Debt; (c) money paid out of a bankrupt's estate to creditors, and reckoned at so much in the £.

D/N—Debit note.

D/O—Delivery order.

Dock and Town Dues—Dues charged for the use of the dock and port; peculiar to Liverpool.

Dock Charges, Dock Dues—Tolls charged to vessels for the use of the docks, tackle, etc.

Dock Warrant—A warrant or receipt for goods in charge of a dock company, giving full particulars as to mark, weight, etc.

Dock Weight Note—See Weight Note.

Document Bills—A set of bills of exchange to which are attached shipping documents—the bill of lading, invoice, marine insurance policy, and letter of hypothecation.

Document Credit—A letter of credit issued on condition that certain specified securities shall be deposited as a collateral security.

Domiciled Bill—A bill of exchange the place of payment of which is inserted at the time of acceptance. The place, usually a bank, is the domicile.

Double Option—See Options.

D.R.—Deposit receipt.

Dr.—Debtor.

Draft—(a) A bill of exchange; (b) the first rough copy of a letter or document; (c) the number of feet a vessel sinks in the water; (d) an order by which money is drawn from a bank; (e) the allowance made by a wholesaler or manufacturer to a retailer for waste by evaporation, the turn of the scale, etc.

Drain of Bullion—The flowing away of a nation's reserve of gold and silver to such an extent as, if not stopped, will leave insufficient for the requirements of trade.

Draw—To fill up a document, such as a cheque, bill of exchange, etc. The one who does this is the drawer; the recipient who has to pay is the drawee.

Drawback—Customs or Excise dues already paid, refunded by the Government on certain classes of goods exported.

Dry Goods—Sometimes used to indicate tobacco, snuff, cigars, dyes, drugs, spices, tea, coffee, chicory, dried fruit, and similar goods; but in America it implies textile fabrics, including shawls, silk, thread, etc., as distinct from groceries.

D/S—Days' sight.

Dues—Charges made for the use of anything, as dock dues, harbour dues, etc.

Dunnage—Anything used to protect a ship's cargo during a voyage—mats, wood, etc.

D/W—Dock warrant.

d.w.—dead weight.

D/y—Delivery.

E & O E—Errors and omissions excepted.

Earnest, Earnest Money—A sum paid by a buyer to a seller to bind a verbal bargain.

E.E.—Errors excepted.

E.I.D.—East India Docks.

Embargo—A Government order prohibiting ships entering or leaving a port, or loading or unloading goods, often enforced in war time.

Emporium—A place where merchants store their goods; also a place for the importation and sale of merchandise.

Endorse—To write one's name on the back of a document, such as a cheque, bill of exchange, etc.

Enfaced Paper—Promissory notes of the Indian Government, so called because of a notification on their face that interest is payable in London by draft on Calcutta.

Entrepot—An intermediate port or warehouse for the temporary reception of merchandise in course of transit to another place.

Entry—To make an entry of goods or to pass Customs entry is to give the authorities full particulars of any merchandise exported or imported, and to pay any necessary duty.

Entry for Warehousing—A Customs document issued when dutiable goods are imported, but are going to be stored in a bonded or Government warehouse till wanted.

Entry Inwards—Customs entry of imported goods.

Entry Outwards—Customs entry of exported goods.

Errors and Omissions Excepted—A phrase, inserted in full or abbreviated thus, E & O E, in an account giving the seller the right to rectify omissions and errors subsequently discovered.

Errors Excepted (E.E.)—A term similar to the last, enabling errors in an account to be rectified.

Even—A Stock Exchange term. Securities are carried over "at even" when there is neither contango nor backwardation to pay.

Ex All—Without dividend, bonus, return of capital, or the right to claim new stocks or shares about to be issued.

Exchange Operation—The giving of one option against another, as, for instance, giving the "call" against taking the "put." See Options.

Exchequer Bills—Promissory notes issued by the Exchequer by Parliamentary authority, and representing the chief portion of the unfunded debt of the country.

Exchequer Bonds—Similar securities to Exchequer bills, but of a more permanent nature, as they run for a longer period.

Ex Cont.—From contract.

Ex Coupon—Without interest coupon.

Ex cp.—Ex coupon.

Ex d.—Ex dividend.

Ex Dividend—Without the dividend that is due or accuring.

Ex Interest—Without the interest due or accuring.

Ex New—Without the right to claim any new stocks or shares about to be issued.

Expected to Rank—The sum which, in a bankruptcy, is expected to be the actual amount owing.

Ex-Ship—A term which means that goods are sold free out of the ship, and the buyer must supply barges to receive the goods.

Ex-Store—Out of the store.

Ex-Warehouse—Out of the warehouse. Where goods are sold ex-warehouse, the buyer must provide his own conveyance to move them from the warehouse.

Ex-Wharf—Off the wharf.

F.A.A. or F.a.a.—Free of all average.

Face Value—The original value named on the face of a document, as distinct from its current market value.

Factor—Same as Commission Agent.

Factorage—A charge made by factors for conducting business for another.

Fair Average Sample—See Sample.

F.a.q.—Fair average quality.

F.a.s.—Free alongside ship.

F.c.s.—Free of capture and seizure.

F.D.—Free docks.

F.g.—Fully good.

F.g.a.—Foreign general average.

F.g.f.—Fully good, fair.

F.i.b.—Free into bunker (coal trade).

Fidelity Guarantees—Policies or bonds issued by guarantee societies, guaranteeing the fidelity of clerks, travellers, etc., and agreeing to make good any defalcations by them. Fixed annual payments are made for such bonds.

Fiduciary Loan—A loan granted to a person without security by a lender who trusts to the borrower's honour.

Fiduciary Note Issue—An issue of notes without any reserve of bullion to meet them.

Figure Code—A code made up of figures representing words and phrases.

Fine Bank Bills—Bills drawn on banks of the first class.

Fine Bills—Same as Fine Paper.

Fine Paper—Bills, drafts, etc., bearing the names of first-class houses and financiers as acceptors or endorsers. Second and third class paper have the name of persons of less standing.

Fine Trade Bills—Trade bills drawn on first-class houses.

First-class Paper—Same as Fine Paper.

First Cost—Same as Prime Cost.

First of Exchange—The first copy of a set of bills of exchange. The other copies are called second and third of exchange. See Foreign Bills of Exchange in Index.

F.i.t.—Free of income tax.
Fittage.—Commission or brokerage.
Fixed Capital—Capital employed in securing and providing land, buildings, machinery, etc., necessary for the making of profits.
Fixed Charges—The charges which a company must pay before dividing profits. Interest and rentals are fixed charges.
F.L.N.—Following landing numbers (marine insurance).
Floaters—Bills and securities held at "call."
Floating a Company—Forming and registering a company.
Floating Capital—The sum in hand and available at short notice for the carrying on of a business.
Floating Debt—Same as Unfunded Debt.
Floating Money—Money in the market available for loans.
Floating Policy—A policy insuring goods that are not all in one place or one ship. If when goods are insured, for instance, the name of the ship carrying them is not known, the policy covers any ship or ships for a specified sum; and as each vessel is fixed, its name and the amount apportioned to it are endorsed on the policy.
Flotsam—Goods found floating after shipwreck. See Jetsam and Lagan.
F.O.—Firm offer.
F/o—For orders.
F.o.b.—Free on board.
Fol.—Folio.
Folio—In bookkeeping, two pages facing each other and numbered alike.
F.o.r.—Free on rail.
Force Majeure—Circumstances over which human beings have no control.
Foreclose—To seize the property on which a mortgage is raised in the event of default or non-payment at the specified time.
Foreign General Average—A term in marine insurance meaning that the underwriters are to pay for any general average according to the average statement made abroad, should it be made there.
For Money—Dealings for money on the Stock Exchange are transactions paid for at the time.
For the Account—Stock Exchange transactions to be settled on the next half-monthly settling day.
Forward—A forward quotation is the price for delivery at a future time. See Spot.
F.o.s.—Free on steamer.
F.o.t.—Free on trucks.
Foul—See Clean.
Foul Bill—See Bill of Health.
F.o.w.—First open water (in chartering).
F.p.—Fully paid.
F.p.a.—Free of particular average.
Free Alongside Ship—A price quoted thus covers carriage and lighterage to alongside the ship, but the buyer must arrange for getting the goods on board.
Free of All Average—In marine insurance this means that goods are insured against total loss only, and that no claim can be made either for general or particular average.
Free of Capture and Seizure—A clause inserted in marine insurance policies in war-time by which underwriters cover themselves against this risk.
Free of Particular Average—Some goods are very susceptible to damage from sea-water, heat, rust, etc., and underwriters only insure such goods "free of particular average." They are not then liable for partial losses from such causes, unless the "ship, craft, or any conveyance, as the interest insured, be stranded, sunk, burnt, on fire, or in collision," when particular average can be claimed.
Free on Board—Prices quoted thus cover the carriage to a port and the charges of putting on board the vessel. The buyer must pay freight.
Free Overside—The same as Ex-ship.
Free Port—A port where no import or export duties are levied.
Freight—The charge made for carriage of goods by water; the money paid for the hire of a ship, barge, etc.; also a ship's cargo.
Freight Engagement—A statement written by the shipbrokers on the back of their shipping card, giving the tonnage engaged and the rate of freight and primage.
Freighter—The charterer of a vessel.
Freight Forward—Freight to be paid by the consignee when the goods arrive.
Freight Note—A debit note sent by the shipbroker to the shipper for the freight of goods shipped.
Freight Receipt—A receipted freight note.
Freight Release—An endorsement on the bill of lading authorising the officer in charge of the ship to deliver goods sent freight forward. It indicates that the freight has been paid.
Funding—The process by which a floating debt is converted into stock.
Frt.—Freight.
F.T.W.—Free Trade Wharf.
Funds—Usually Consols and other securities of the British Government. Also stock or capital, and money, the income of which is set apart for some specific object.
Futures—Goods to be shipped at some future time, as distinct from "spot" stocks and goods "on passage."

G—Gauge.
G.A. or **G/a**—General average.
Garble—Dross or refuse picked from spices, drugs, tobacco, etc., in sorting.
Garbling—Separating the bad or damaged portions of goods from the sound portions.
Garbling Coin—The practice of some money-dealers who separate full-weight coins from light and worn ones, passing the latter into circulation again and melting the former for the manufacture of jewellery or gold leaf.
Garnishee—A person who owes money to or holds the property of another who is a judgment debtor.
Garnishee Order—A notice sent to a person owing a judgment debtor money, or holding his goods, declaring he is not to part with such money or goods until the claim against the debtor is settled. This prevents the debtor obtaining the goods and using them for himself instead of for his creditors.
Garnishment—The notice sent to garnishees.
Gauger—An Excise or Customs officer who measures and examines vessels containing dutiable liquids.
Gauging Rod—The instrument used in measuring the contents of casks, barrels, etc.
General Acceptance—See Acceptance..
General Ship—A ship chartered, but not for any particular voyage or cargo.
Give On—To pay contango.
Giver—Same as Bull.
Glut—An over-supply of any commodity.
G.m.b.—Good merchantable brand.
G.m.q.—Good merchantable quality.
G.o.b.—Good ordinary brand.
Godown—A term used in the East for a warehouse, usually underground, where imported goods are stored till required.
Gold Bonds—Bonds payable in gold.
Gold Movements—Arrivals and shipments of gold bullion and coins.
Gold Premium—The rate by which the value of a paper currency is exceeded by that of gold which it represents.
Good Merchantable Quality and Condition—A phrase used in contracts, meaning that goods must be up to ordinary quality and condition.
Goods—Goods train.
Good Until Cancelled—This condition attached to an order to a stockbroker to buy or sell means that the order remains in force until countermanded. Often abbreviated to G.T.C.
Goodwill—The value of an established business connection, including all the advantages the existing owner possesses of carrying on the business.
Gr.—Gross.
Grace—See Days of Grace.
Grande Vitesse—French for fast goods train.
Graving—Cleaning a ship's bottom.
Great Gross—Twelve gross.
Great Hundred—120 articles.
Greenbacks—United States paper currency.
Gresham's Law—The declaration by Sir Thomas Gresham that: Where two sorts of coins are current in the same nation, of like value by denomination, but not intrinsically, that which has the least value will be current, and the other as much as possible hoarded or exported."
Gross—Twelve dozen. See Great Gross.
Groundage—A charge made in certain ports for allowing a ship to anchor there.
Ground Price—Continental term for basis price.
Gr. wt.—Gross weight.
G.T.C.—See Good Until Cancelled.
Guarantee Society—A society which issues fidelity guarantees, which see.

HAMMERED—When a member of the Stock Exchange finds himself unable to meet his engagements, the head waiter, as the porter is called, strikes three blows with a hammer on the rostrum in the "House" and announces the default. The member is thus said to be "hammered."
Handsel—Earnest money.
H. A. or D.—Havre, Antwerp, or Dunkirk. (Used in grain trade.)
Harbour Dues—Tolls paid by ships for the use of a harbour, with landing-stages, etc.
Harden—To advance in price. Used of stocks and shares.
Hatchway—Same as Hatches.
Hat Money—Same as Primage.
Haulage—A charge by a railway, dock, or canal company for carrying goods from place to place. It does not include loading or unloading.
H.B.C.—Hudson's Bay Company.
H.C.—Held covered (by insurance).
Heavies—Same as Heavy Stock.
Heavy Stock—The stock of railway companies having a heavy goods traffic.
Heritable Bonds—Bonds with a conveyance of land attached, given as security for the repayment of money. If the bond is not honoured or the interest paid, the conveyance becomes available.
H H—Havre and Hamburg. (Used in grain trade.)
Hhd.—Hogshead.
High Seas—All seas except those within three miles of countries with a seaboard. The seas in the three-mile limit are called territorial waters or mare clausum (Latin for closed sea).
H.M.C.—His Majesty's Customs.
Hold—The hollow part of a ship in which the cargo is placed.
Holder—The person in possession of a bill of exchange or other document.
Holding the Market—Preventing a decline in the price of a security by buying it as it is offered.

Home Use Entry—A Customs document used when dutiable goods are to be taken from a warehouse for home consumption.

Hong—The name given by the natives to any European factory in China.

Hong Name—A brand mark in Chinese characters used by merchants in China to distinguish their own particular goods.

Housing—Warehousing.

Hypothec—In Scotland, a lien given to a creditor upon the property of his debtor, possession remaining with the debtor.

Hypothecation—The giving of a lien upon property or the pledging of documents conveying right thereto, while still retaining possession of the property; contrasted with pawning, where the property is handed over to the creditor.

Hypothecation Bond—A bottomry bond or respondentia bond.

I.B.—Invoice book.

I.B.I.—Invoice book inwards.

I.B.O.—Invoice book outwards.

Impersonal Accounts—Accounts dealing not with persons, but with things, such as petty cash, charges, etc.

Imposts—Taxes levied on merchandise, particularly on imports.

Impressed Stamp—A stamp not stuck on, but impressed on a document in payment of stamp duty.

In Ballast—A vessel is said to be in ballast when she has no cargo, but carries ballast, such as gravel, flints, stones, etc., to keep her steady in the water.

In Clearers—Bank clerks who attend the Bankers' Clearing House and receive all cheques drawn upon their banks. See Out Clearers.

Inconvertible Paper Currency—Paper money which cannot be exchanged for coinage on demand.

Indemnity—Compensation for losses or injury. See also Letter of Indemnity.

Indent—Originally an order sent to a merchant by his clients abroad for some particular brand of goods, the manufacturer and price of which are specified. Now, however, any order from abroad for the purchase of goods is spoken of as an indent.

Indentures—Written agreements between parties, each of whom retains a copy.

Indirect Exchange—Exchange operations between two countries, through the medium of one or more other countries.

Indorse—See Endorse.

Inland Bill—A bill of exchange drawn by one person or firm on another within the British Isles.

Inscribed Stock—Stock for which certificates are not issued to the holders, but their names and holdings are entered in a register at the bank where the stock was issued.

Inside Broker—A broker who is a member of the Stock Exchange.

Inspecting Order—An order to a dock company or wharfinger to allow the bearer to inspect and sample goods lying at the dock or wharf.

Inst.—Instant; meaning "of the current month."

Int.—Interest.

Interbourse Securities—Securities the loans for which were raised simultaneously in different countries.

Interdict—An interdict at port of discharge is a clause in a bill of lading forbidding entry of a port.

Interest Policy—In marine insurance, a policy in which some real and specified interest is insured, as 100 boxes of oranges.

Interest Warrant—An order for the payment of dividends on public stocks.

Interim Dividend—A provisional distribution of profits, before the actual dividend is due, or before the complete profits for the year are known.

In Transitu—In course of transmission.

Inv.—Invoice.

Inventory—A list of goods, fixtures, etc., made either for reference or for a sale.

Invoice Book—A book containing copies of original invoices.

I.R.O.—Inland Revenue Office.

Issue Par—The price at which a security is first sold, irrespective of its actual face value.

Issue Price—The price at which an issue of securities is offered to the public.

J/a—Joint account.

Jerquer—A Customs official who searches vessels for smuggled goods that should pay duty.

Jerquing—The searching of a ship by a jerquer.

Jetsam—In marine insurance, goods which, to lighten a ship, have been thrown overboard and sunk, and which remain under water. See Flotsam and Lagan.

Jettison—To lighten a ship by throwing overboard cargo or tackle.

Job—To deal in merchandise on one's own account, and not as an agent or broker.

Jobber—One who jobs in any article. In a more restricted sense a jobber is a stock dealer who carries on business with the public and other jobbers through stockbrokers.

Joint Account—Two or more firms trade upon joint account when the profits or losses which each makes are equally divided among all.

Joint Stock—Stock which is held jointly by a number of persons.

Joint-stock Bank—A joint-stock company carrying on the business of a bank.

Joint-stock Company—An association of individuals for purposes of profit, possessing a common capital contributed by the members composing it, such capital being divided into shares, of which each possesses one or more, and which are transferable.

Judge's Order—An order made by a judge in an action to recover a debt, by which proceedings are stayed upon the debtor undertaking to pay the debt and costs within a specified time.

Judgment Debtor—One who is ordered to pay his creditor by a court of law.

KEELAGE—Tolls charged to a ship for entering and resting in certain ports and harbours.

Kentledge—Ballast for a ship, consisting of iron castings known as "pigs."

Kite—See Accommodation Bill.

Kite-flying—Dealing in accommodation bills so as to raise money to maintain one's credit.

Knot—A nautical mile of 6080 feet.

£—Pounds sterling, placed before the figure, £20.

l—Pounds sterling, placed after the figure, 20*l*.

l/a—Lettre d'avis, letter of advice.

Lac—100,000, as in lac of rupees. Also spelt lakh.

Laches—In commercial law, an act of negligence or carelessness entailing inconvenience or loss to the person committing it. An example is a banker paying a cheque which a little care would have shown to be forged.

Laden in Bulk—The term used when a ship's cargo is filled loose into the hold, but properly dunnaged to prevent loss.

Lagan—Heavy goods cast into the sea by jettison, which sink, but have a cork or buoy attached so that they may be found again. See Flotsam and Jetsam.

Lakh—See Lac.

Lame Duck—A Stock Exchange term for a defaulter.

Land Carriage—Conveyance of goods by road or rail.

Landing Account—A dock company's account of goods landed, with full particulars of weight and condition.

Landing Book—A book kept by dock companies and warehouse keepers, in which are entered full details of all goods landed, and from which landing accounts are made out.

Landing Order—A Customs document handed to the chief officer of a ship, authorising him to allow goods to be landed, the importer having passed entry and paid any duty that is due.

Landing Waiter—See Land Waiter.

Landing Weight—The actual weight of goods as landed from a ship.

Land Waiter—A Customs official who examines, weighs, measures, tastes, etc., goods liable to duty and makes a record in a book. In the case of goods exported he certifies that they are shipped according to prescribed form.

Lastage—Sand or ballast placed in a ship to keep her steady.

Law of Merchants—See Lex Mercatorum.

Lay Days—Days allowed for loading or unloading ships as agreed upon between owners and charterers. Lay days begin directly permission to load or unload is given.

Laying Days—Same as Lay Days.

Lazaretto—A building or ship where goods, letters, baggage, etc., from ships in quarantine are fumigated.

lb.—pound (weight); the plural is lb., not lbs.

L/C—Letter of credit.

L.D.—London Docks.

Ld.—Limited.

£E—Egyptian pounds (£1 0s. 6¼d. sterling).

Leakage—An allowance made for loss or waste in liquids.

Led—Ledger.

Legal Quay—A wharf licensed by the Customs authorities for the landing and storage of bonded goods.

Legal Tender—The authorised coins that may be legally tendered in payment of debts. In the United Kingdom they are gold up to any amount, silver up to two pounds, pence and halfpence up to a shilling, and farthings up to 6d. Bank of England notes are also legal tender up to any amount, but not exceeding the debt, as no one but the Bank itself is obliged to give change for a note.

Legan—See Lagan, of which it is only another spelling.

Letter of Allotment—The formal document sent to an applicant for shares in a public company, stating the number of shares allotted to him. If under the nominal value of £5, the stamp duty is one penny; if over £5, sixpence.

Letter of Attorney—See Power of Attorney.

Letter of Credit—A letter given by a banker or merchant authorising his agents to pay money to the bearer.

Letter of Hypothecation—A formal letter giving a person a lien over goods in consideration of an advance of money. See also Hypothecation.

Letter of Indemnity—A letter from a manufacturer to a merchant, guaranteeing the latter against loss or claim through goods having been shipped not in good order and condition, or through the number of packages being disputed.

Letter of Indication—A letter issued with a circular note, describing the bearer and giving a copy of his signature. It must be produced when the note is presented for payment.

Letter of Licence—A document signed by the creditors of a person insolvent or in difficulties, allowing his business to be carried on for a specified time without payment of their claims.

Letter of Marque—A Government licence granted in time of war, authorising merchants to fit out privateers to prey upon the enemy.

Letter of Renunciation—A letter sometimes sent with a letter of allotment, giving the allottee the right to renounce the shares allotted to him. He exercises the right by signing the letter of renunciation.

Letters Patent—An open writing sealed with the Great Seal of England, giving a person the sole right for a certain number of years of making use of an invention of which he is the author. The invention is then a patent.

Lettre de Change—French for bill of exchange.

Lettre de Créance—French for letter of credit.

Lex Mercatorum—Called the Lex Mercatoria and the Law of Merchants. The usages and customs that regulate commercial matters among civilised peoples.

Levant—The coasts of the Mediterranean east of Italy.

L.H.A.R.—London, Havre, Antwerp, Rouen (grain trade).

Lien—A legal right of claim upon goods, etc., usually granted as security for debt.

Lien Maritime—A lien applying to ships freight, or cargo, and arising by law or by special contract. Seamen have a lien on a ship for their wages.

Light Dues—Tolls levied by the Custom House on ships for the maintenance of beacons, buoys, lighthouses, etc.

Light Gold—Gold coins that have become light in weight through wear or other causes.

Lighterage—The charge made by lightermen for the use of their lighters or barges when conveying goods for others.

Limit—A price fixed at which a purchase or sale is to be made. See Low Limited.

Limitations, Statute of—The time within which action must be taken where an injury has been done or a debt incurred. For most commercial transactions this is six years, as for debts, arrears of rent, actions for trespass, the negotiation of bills or notes, bank balances and deposits.

Limited and Reduced—A limited company whose capital has been reduced from its original amount.

Limited Company—Short for Limited Liability Company; a public company in which the shareholders cannot be called upon to subscribe more than the nominal value of the shares held by them.

Liquid Assets—A bankers' term for coin, banknotes, and securities which can be converted at once into cash.

Liquidated Damages—Damages, as in a charter party clause, the amount of which has been agreed upon.

Liquidation—The winding up of a business. A public company in course of being wound up is said to be "in liquidation."

Lloyd's Bonds—Promissory notes, bearing interest payable to bearer, issued to evade the Mortgage Debenture Act, which prohibits a company borrowing more than a sum equal to two-thirds its paid-up capital. Named after their originator, a barrister named Lloyd. Lloyd's bond is also the term used for a form of agreement authorised by the Committee of Lloyd's protecting shipowners from losses already suffered by a ship. It differs from a policy, which is issued before a ship sails.

Lloyd's Policy—The form of policy authorised by the Committee of Lloyd's.

Loan Rate—A money-market term for the rate of interest paid for money advanced against a deposit of securities.

Lockage—Dues paid for passing boats through locks.

Locker's Orders—Forms in which can be set forth particulars of goods to be exported, printed on the back of bond notes.

Log Book—A book in which the captain keeps a daily record of his ship's voyage, the winds, weather, course.

Lombard Street—A newspaper term for the open money market.

Long—An American Stock Exchange term similar to the English "bull." The person who holds stock for a rise is said to be "long of stock."

Long Bill—A bill of exchange having a long term to run.

Long-Dated Bill—Same as Long Bill.

Long Dozen—Thirteen articles reckoned as twelve.

Long Hundred—120 articles.

Lot—A portion, pile, or parcel of goods set apart for a purpose, as for shipment or sale.

Lot Money—An auctioneer's commission of so much for each lot sold by him at an auction.

Low Limited—A limit that is unworkable and is therefore referred back. See Limit.

L.S.—Locus sigilli, the place for the seal on a document.

£ s. d.—Pounds, shillings, pence; from Latin: libræ, solidi, denarii.

£T—Turkish pounds.

Ltd.—Limited.

M.—Monsieur.

M or m—Thousand, as 200m = 200,000.

Made Bill—A bill with the name of a third party upon it in the form of one or more endorsers.

Mail Steamer—A steamer chartered to carry the royal mails.

Making-Up Day—See Settlement.

Making-Up Price—Stock Exchange term for the price at which stocks and shares are closed for the settlement and reopened for the next account.

Manifest—A statement made out by the captain of a ship before sailing, giving full details of the cargo, with marks, weights, consignees, etc., particulars of the ship and crew, and her ports of destination. This is lodged at the Custom House before leaving or when entering a port. A copy can usually be seen at the shipbroker's office.

Margin—(1) Cash or securities required by a banker over the amount of money lent, to provide against depreciation of the securities deposited with him. (2) Another name for "Cover," which see. (3) A discretion of so much per cent. or per share allowed to a broker over a named price, if business should be impossible at the figure fixed.

Mariners—In shipping documents, the sailors and officers outside the captain and pilot.

Maritime Law—The branch of commercial law relating to ports, harbours, ships, seamen, pilots, navigation, lighthouses, buoys, etc.

Marked Cheque—A cheque marked by the bank on which it is drawn, as good for the amount named on it.

Marked Transfer—Same as Certified Transfer.

Market Days—The fixed days when certain Exchanges like the Coal Exchange, the Corn Exchange, etc., are open.

Market Price—The current price at which goods are being bought and sold in the market.

Market Rate of Discount—The rate charged by bankers and billbrokers for discounting bills of exchange.

Market Report—A report describing the condition of the market, the prices ruling, etc., sent to merchants and traders on market days.

Market Value—The sum that can be obtained for goods or securities in the open market.

Marking—Posting up on the marking-board at the London Stock Exchange the prices at which a bargain or transaction between members has been effected. Such postings are called markings.

Mart—A contracted form of market.

Martinmas—November 11, one of the Scottish quarter-days.

Master—The captain or navigator of a ship.

Master's Copy—See Captain's Copy.

Mate's Receipt—The receipt signed by the mate for goods received on board ship. It is afterwards exchanged for the bill of lading.

Mature—A bill matures when it becomes due.

Maturity—The date when bills, drafts, etc., become due.

M/C—Metalling clause (marine insurance); marginal credit (banking).

M.D.—Millwall Docks (London).

M/d—Months' date: that is, months after date.

Measurement Account—See Measurement Goods.

Measurement Goods—Goods on which, owing to their light weight and great measurement, freight is charged by measurement instead of by weight. Forty cubic feet are reckoned as a ton. The account taken by the dock company and shipbroker for such goods, showing length, breadth, and depth of the cases, is called the measurement account.

Memorandum of Association — A stamped document setting forth the objects, capital, etc., of a limited liability company.

Metalling Clause—In marine insurance, a clause specifying that no claim can be made on the underwriters for ordinary wear and tear to a steamer below the water-line. The clause usually reads: "Warranted free from particular average below the load water-line, unless occasioned by fire or contact with some substance other than water."

Metric System—The system of weights and measures, now adopted in most countries, founded on decimals.

M.H.—Main hatch (shipping).

Michs.—Michaelmas.

Middle Price—The central price between those at which a dealer is willing to buy and sell.

Mint-par of Exchange—The intrinsic value of the unit of currency of one country as compared with the intrinsic value of the money in the currency of another country, determined by the weight and fineness of the coinage in the two countries.

Minute Book—A book in which are entered the minutes of the meetings of a pubc company or its directors.

Minutes—The gist of the proceedings at a company or directors' meeting, together with particulars of all resolutions. See page 2088.

M.I.P.—Marine Insurance Policy.

Mixed Currency—A currency consisting partly of the precious metals and partly of paper, both being legal tender.

Mixed Policy—In marine insurance, a policy insuring a ship from one place to another for a given period, making it both a voyage and a time policy.

Mks.—Marks (German coin).

M/m—Made merchantable (see Merchantable).

MM.—Messieurs, gentlemen, sirs.

Mo.—Month.

M.O.—Money Order.

Money Market—A general term for money transactions of all kinds, such as the dealings of bankers, bill-brokers, capitalists, money-changers,

Mono-metallism—A money currency based on a single standard of value, as in England, where gold is the only standard coin. Silver and bronze coins are merely token money, which see.

Monopoly Contract—A contract whereby a merchant buys up some manufacture, the manufacturer agreeing not to sell to others in the same market.

Month—In a bill of exchange, a calendar month; a half month is fifteen days.

M.O.O.—Money-order office.

Moratorium—An extension of time for the payment of debts, granted by a Government in exceptional circumstances, such as the Great War.

Mortgage—The pledging of property as security for debt. If the interest is not paid, the lender may seize the property.

Mos.—Months.

M.R.—Mate's receipt.

M.S.—Mail steamer.

M/s—Months' sight: that is, months after sight.

M.S.C.—Manchester Ship Canal.

M/u—Making up (Stock Exchange settlement).

Multiple Telegrams—Telegrams with identical wording sent to several persons in the same place or to one person at several addresses in the same place.

Muster—A sample. To "pass muster" means that the bulk is equal to the sample.

Muster Roll—A list of persons, passengers and crew, on a ship, with particulars as to name, address, age, sex, profession, etc., of each.

Mutuum—In mercantile law, something lent, with or without interest, in such a way as to imply an exchange for something equivalent.

N/A—No advice (banking).

N/a—Non-acceptance.

Name Day—The second day of the settlement on the London Stock Exchange. Same as Ticket Day.

Named Policy—A marine insurance policy in which the vessel's name is inserted at the time the insurance is made.

Navy Bills—These are of two kinds: (1) Bills issued by the Admiralty in payment of stores supplied to Government ships or dockyards; and (2) Short-dated bills drawn by naval officers on the Accountant-General for pay due.

N.C.—New charter; new crop; new account (Stock Exchange).

N/e—No effects.

Negotiable Document—A document which, when transferred, carries with it the legal right to the property specified therein.

Negotiable Instruments — Documents that are transferable by endorsement and delivery from one person to another, such as bills of exchange, promissory notes, etc.

Negotiable Paper—Same as Negotiable Instruments.

N/f—No funds.

N/m—No mark.

N/O—No orders (banking).

Nom.—Nominal.

Nos.—Numbers.

No Funds—A phrase endorsed by a banker on a cheque, the drawer of which has no funds to meet it, before returning the cheque to the person who paid it in.

Nominal Partner—A person with no real interest in a business that is carried on in his name, with his consent, as, for example, where a change of name might injure the reputation of a concern.

Nominal Price—An approximate price, given where the exact price can only be known after the transaction is completed.

Notary Public—An official authorised to attest, copy, or translate written documents. It is also the notary's duty to present for the second time dishonoured or non-accepted bills, protesting against and noting the dishonouring.

Note of Hand—A promissory note.

Notice of Dishonour—Notice that must be given by the holder of a bill to those who drew it or negotiated it, when the bill is dishonoured. See Dishonouring a Bill.

Noting a Bill—When a bill of exchange is returned dishonoured, the holder takes it to a notary public, who again presents the bill to the drawee. If it is not then accepted or paid, the notary makes a minute in his protest book of the answer given, writes on the bill his initials, the date, and his charges, and on a slip of paper the reason for non-acceptance. This is noting the bill.

Not Negotiable—An endorsement on a cheque which means that "the receiver shall not have, and shall not be capable of giving, a better title to it than that which the person from whom he took it had."

N/p—Non-payment.

N.P.—Notary public.

N.R.—No risk (insurance).

N/S or n/s—Not sufficient (banking).

N/t—New terms (grain trade).

Nursing an Account—If a banker who has made an advance on an unmarketable security finds that should he call up the loan the party would break, and the bank be the loser, he will often, instead of realising the security at once, lock it up, in the hope of selling it better later on, or in the hope that the borrower will be able to redeem his pledge. This is called "nursing the account."

O/a—On account of.

Obligation—A bond that contains a penalty and has a condition attached for the performing of a covenant, payment of money, etc.

Obs.—Obligations.

Obscuration—A Customs term for the difference between the strength of spirit indicated by the hydrometer and the true or actual strength.

O/c—Old charter; old crop; overcharge.

Octroi—A tax levied at the gates on goods brought into a city.

O/d—On demand.

O.D.O.—Outdoor officer (Customs).

Official Minimum—A term used for the current Bank rate.

Official Receiver—An official appointed by the Bankruptcy Court to manage the estate of an insolvent person during the liquidation of his affairs.

Omnium—The total value of the various kinds of stock forming a loan.

On 'Change—Members of the various Exchanges are said to go "on 'Change" when they attend a meeting at the Exchange. Stock Exchange members, however, are said to "go down to the House."

On Demand—A term used on a bill of exchange that is payable on presentation, and does not need to be accepted.

One and One—One month's prompt cast with 1 per cent. discount.

On the Berth—A vessel is "on the berth" when she is at the place where she loads or discharges her cargo.

Onus Probandi—The burden of proving —a term used in law.

%—Per cent.

‰—Per thousand.

Open Account—In bookkeeping, an unsettled account.

Open Credit—A term used when a letter of credit contains an unconditional request to pay money to a person.

Open Policy—In marine insurance, a policy in which, at the time the insurance is effected, it is stated that the interest is to be hereafter declared. This kind of policy is issued when the value of a cargo cannot be exactly fixed, and a sum is estimated and afterwards adjusted.

Option—The right of choice to buy anything during a specified time.

Option Money—Money paid to secure an option.

Options—A method of Stock Exchange speculation, a person paying down so much per cent. or per share for the option or right to "call"—that is, to buy—so much stock at a fixed price on a certain day, or for the right to "put"—that is, to sell—in the same way. Either case is called a "single option." The right to "put and call" is called a "double option." The right to put a certain amount of stock, with the option of doubling it, is called "put of more."

Ord.—Ordinary stock or shares.

Original Bill—A money-market term for a bill drawn and sold prior to having any endorsement.

Or Order—Bills of lading, delivery orders, etc., are made out to So-and-so, "or order," and this means that the goods will be delivered to him upon his endorsement, or he may endorse them over to another by naming the party in the endorsement.

Out Clearers—Bank clerks who receive cheques and arrange them alphabetically according to the banks on which they are drawn, ready for the In Clearers, which see.

Outport—Any port in the kingdom away from the main Custom House at London.

Outside Brokers—Stockbrokers who are not members of the Stock Exchange.

Over-capitalised—A company is over-capitalised when it is unable to earn sufficient profits to pay adequate interest on the shares issued.

Overhead Price—Same as All-round Price.

Over-insurance—A marine insurance term for when the value of the goods amounts to less than the sum insured. The difference is called short interest.

Over-takers—Extra packages used when goods bulked by the Customs cannot be completely replaced in the original packages.

Over-tonnage—The excess of ships over the freight available.

Over-trading—Trading beyond the capital available.

P.—Per or page.

P/A—Power of attorney; private account.

P.A.—Particular average (marine insurance).

Packing—The charge made for packing goods.

Paid-up Capital—The amount of capital paid on shares that are not fully paid up.

Paid-up Shares—Shares on which all that has to be paid is already paid up.

P. & L.—Profit and loss.

Par—A term used when the price of a security is the same as its nominal value. See "Above Par" and "Below Par." Also, when the money of two countries is equal is value, the exchange is said to be at par.

Parole—A word used to describe verbal arrangements, as an agreement made by parole.

Parquet—The sixty official brokers or Agents de Change on the Paris Bourse.

Partial Loss—Damage sustained by a ship or cargo during a voyage, for which the underwriters are liable to the owners. The policy, however, always has a clause declaring that the underwriters will not be responsible for partial loss when it does not amount to a percentage named. This is to prevent continuous, trifling demands.

Part Owners—Private shareholders of ships.

Par Value—The face value of securities.

Pass-book—A book given by a bank to a customer, showing all moneys received and paid. It is actually a copy of the customer's ledger account at the bank.

Passing a Name—A Stock Exchange term for giving the name of the actual purchaser at the settlement.

Passive Bonds—Bonds that do not bear interest, but entitle the holder to some future benefit or claim.

Patent—See Letters Patent.

Patentee—A person who owns a patent.

Pay Day—The last day of the Stock Exchange settlement, when shares are taken up and paid for, or differences settled. Also called settling day.

Paying-in-Slip — The memorandum handed to a bank with notes, bills, cheques, cash, etc., showing how much of each and the total amount paid in at the time.

P/C—Petty cash; price current.

p.c.—Per cent.

pc.—Piece or price.

P.C.B.—Petty-cash book.

pcs—Pieces or prices.

Penalty Clause—A clause in a contract imposing a penalty on the seller in case of the non-fulfilment of conditions specified.

Per Contra—A bookkeeping term, meaning "on the other side."

Per Diem—By the day.

Perils of the Sea—In shipping documents, the ordinary perils of a voyage.

Per Mille—Per thousand, written %o.

Permit—A permission granted by the Customs for the removal of goods on which duty has been paid; or a licence from the Excise allowing excisable goods to be moved from one place to another.

Per Pro.—See Per Procuration.

Per Procuration—A procuration is a written document empowering a person to act and sign for another. When so signing, the term is placed in front of the signature, abbreviated to per pro., p.p., or p. pro.

Personal Accounts—In bookkeeping, the accounts of persons set forth under their names.

Personal Estate—Money, goods, debts and rents due, leasehold property, furniture, insurance policies, stocks, shares, etc.

Personal Security—A document giving the holder a claim on a person for a specified sum.

Personalty—Personal estate and movable property of all kinds.

Petite Bourse—The evening market of the Paris Bourse.

Petite Vitesse—French for ordinary goods train.

Petitioning Creditor—The creditor who files a petition to the Court asking for the debtor to be made a bankrupt.

Petties—A bookkeeping term for small items, too small to be separately specified.

Petty Average—An allowance for towing, etc., now generally included in the freight.

Piece Goods—Goods sold by the piece, such as calicoes, muslins, handkerchiefs, carpets, etc.

Pierage—A charge for the use of a pier (with tackle, etc.) to which a boat is moored or where goods are landed.

Pkg.—Package.

P.L.—Partial loss (marine insurance).

Plain Spirits—Spirits in the original state, with no artificial flavouring added.

Plaint—A legal term for the written statement of grievance against a defendant.

Pleadings—The statements of parties in a lawsuit.

P/m—Put of more. See Options.

pm.—Premium.

P/N—Promissory note.

P.O.B.—Post-Office box.

P O.D.—Pay on delivery.

Policy—A stamped contract of insurance.

Policy Proof of Interest—A term meaning that, in the event of loss, the insured person may recover from the underwriters on the production merely of the policy containing this clause. It is inserted in wager policies, which see.

Pool—A combination of persons to operate jointly in stocks, shares, produce, etc.

Post—To post a book is to make an entry in it, or to transfer an account from one book to another.

Post-date—To date a document with a date later than that on which it is actually signed.

Post Entry—An additional entry made to cover goods beyond those in the original entry. See Entry and Prime Entry.

Post-obit Bond—A bond payable only after the death of the person named in it.

Poundage—A charge of so much in the £, as for a postal order.

Power of Attorney—A legal document by which a person appoints another to act for him. A general power of attorney authorises the agent to act in all matters or in a particular business. A special power authorises for some specified act only.

P.P.—Parcel post.

p.p.—Picked ports (in chartering).

P.p.i.—Policy proof of interest (marine insurance).

Précis—An abstract or summary of a document.

Pref.—Preference or preferred.

Preferred Stock—Sometimes called "B" stock. Part of the ordinary stock entitled to a fixed rate of dividend before anything is paid on "A" or deferred stock, which see.

Premium—(1) A bounty; (2) an annual payment to effect an insurance; (3) a payment for a loan in addition to interest; (4) the difference between the par and current market price of anything, in contradistinction to discount. Such an article is spoken of as being "at a premium."

Pressure—A money-market term, implying difficulty in obtaining money, discounting bills, etc.

Price Current— A list issued by merchants to their customers, setting forth the current market price of the articles they deal in.

Pricking Note—A shipping order from the Custom House to a ship's captain requesting him to take on board bonded or drawback goods for export or ship's stores. See Dandy Note. Dandy and pricking notes are usually combined in one document.

Primage—Formerly an allowance given by the shipper or consignee to a ship's master, over and above the freight. It is now reckoned as a percentage added to the freight for the use of cables, ropes, etc., in loading and unloading. Also called "hat money."

Primage and Average Accustomed—A phrase used in bills of lading. The average is a charge by the ship on the owners of the cargo to cover certain expenses, lights, pilotage, etc. It is generally included in the primage charge.

Prime Cost—The cost of an article before charges or profits are added.

Prime Entry—A provisional Customs entry before goods are landed. After examination and weighing, a post-entry is made of them.

Principal—(1) The head or chief person in a firm; (2) the capital sum upon which interest is paid.

Private Arrangement—An understanding between an insolvent trader and his creditors allowing him to carry on or liquidate the business under specified conditions, instead of going through the Court. This is to save bankruptcy costs. The deed must be registered.

Private Bank—A bank with not more than ten partners.

Private Company—A limited liability company which by its articles restricts the right to transfer its shares, limits the number of its members to fifty, and prohibits any invitation to the public to subscribe for shares.

Private Discount—A foreign money market term for the outside discount rate as distinct from the discount rate of the national bank.

Privileges—An American term for options.

Pro.—For, used by employees when signing for a principal.

Pro Forma—For form's sake. A pro forma account is an account made up to show the charges, commission, etc., on goods which may be ordered or consigned. A pro forma invoice is an invoice which merchants often receive when asked to buy certain goods out of their ordinary line, so that they may know the current price of the goods, cost of packing, discount, etc. When a merchant consigns goods to an agent for sale, he sends a pro forma invoice to give the consignee some idea of the price that is expected.

Prohibited Goods—Goods which may not legally be either imported or exported.

Prohibitions and Restrictions—A Customs term for goods which may not be legally imported or exported, or on which there are restrictions.

Promissory Note—A written promise by a person to pay a specified sum to a certain person named, to his order, or to bearer on demand or on a certain date. Promissory notes are liable to duty, and must be written on stamped paper.

Promotion Money—The sum paid to a person for his work in bringing a public company into existence.

Prompt—The time fixed for the payment of goods, as prompt seven days, meaning that payment is to be made a week from date.

Proof in Bankruptcy—Proof by affidavit of a claim made on a bankrupt's estate.

Property Accounts—In bookkeeping, the different kinds of goods dealt in, such as rope, sugar, etc.

Proprietary Company—A parent company which lets out or sells its property to other public companies, as in the case of land let to a mining company.

Protest—A stamped declaration made through a notary public, that a bill has been presented, and was refused, and that the holder intends to recover all damages sustained. See also Ship's Protest.

Proviso—A provision or condition.

Prox.—Short for proximo, the next succeeding month.

Proxy—One who acts for another; also the deed empowering him to act.

P/S—Public sale.

Public Company—A joint-stock or limited liability company amenable to rules and regulations laid down by Act of Parliament.

Public Funds—See Funds.

Purser—The cashier of a ship or of a mine.

Put—See Options.

Put of More—See Options.

QUALIFIED ACCEPTANCE—See Acceptance.

Quarter Days—In England and Ireland these are Lady Day, March 25; Midsummer Day, June 24; Michaelmas Day, September 29; Christmas Day, December 25. In Scotland they are Candlemas Day, February 2; Whitsunday, May 15; Lammas Day, August 1; Martinmas Day, November 11.

Quayage—The charge for using a quay.

Quittance—A discharge from a debt or other obligation.

Quorum—The least number of persons, as arranged by the rules, that makes a meeting legally capable of transacting business.

R—Rupees.

Racking—Customs term for drawing off wine or spirits from the lees; also for transferring from a large cask to smaller ones, from small casks to a large one, or from an unsound cask to a sound one.

Rack Rent—A rent which is the extreme value of the thing rented.

Rateable Value—The value of property after deducting an allowance for repairs, etc.

Rate of Exchange—The amount given in one country's currency for a sum in another country's currency. Rates of exchange fluctuate.

Raw Materials—Materials in their natural state before being used in manufacture.

R/D—Refer to drawer (banking).

R.D.C.—Running-down clause.

Re—In regard to.

Real Estate—In contradistinction to movable property, which is personal estate. This consists of manors, tithes, advowsons, copyhold and freehold property, etc.

Rebate—An allowance in price. In banking it is an allowance given in consideration for taking up a bill of exchange before it has matured.

Receiving Note—A note addressed by the shipper to the chief officer of a vessel, asking him to receive on board the goods specified.

Re-draft—A new bill of exchange drawn by the holder of a protested bill on the drawer or endorser, for the original amount, with costs and charges.

Re-exchange—A charge made upon the drawer of a dishonoured foreign bill of exchange when the holder redraws a fresh bill.

Reference—A declaration as to a person's commercial integrity.

Registered Bond—Bonds registered in the holder's name in the books of the company issuing them.

Registered Offices—The official address of a company, so called because it is the address registered at the Joint Stock Companies Registry. It is the place where all legal and other notices to the company must be served.

Registered Stock—Stock registered in the holder's name at the bank or office where it was issued.

Register of Members—See Share Register.

Re-insurance—When an underwriter fears he has taken too great a risk, he re-insures his interest with other underwriters at a higher premium, and this is called a re-insurance.

Release—A document setting a person free from an engagement.

Re-lease—To grant a new lease.

Renew a Bill—To accept a new bill of exchange in place of an old one that the debtor could not meet.

Rentes—The annual interest payable on French, Austrian, Italian, and Greek stocks.

Report—To report a ship is to pass all the Customs formalities, so as to obtain permission for unloading.

Re-rummage—A ship is rummaged when unloading and re-rummaged when being loaded. See Rummage.

Respondentia—A loan raised on the cargo of a ship on the personal responsibility of the master. If the vessel be lost, the lender loses his money. See also Bottomry.

Rest—In banking an accumulation of undivided profits, after payment of dividends, kept as a reserve to meet possible losses.

Restrictive Endorsement—An endorsement on a bill of exchange that has been endorsed over to another person, preventing him from transferring it again, or restricting him from dealing with it otherwise than as directed in the endorsement.

Retire a Bill—To pay a bill when it becomes due.

Retire a Bill Under Discount—To take up a bill before it is due, the holder allowing a discount on it.

Return of Premium—In marine insurance, the return by the underwriters of the overplus when anything has been insured for more than its actual value.

Returns—(1) The amount of sales for a given period; (2) a report of transactions; (3) cases returned by a purchaser, after he has removed the goods sent in them; (4) tabulated statistics; (5) an account of goods taken on board ship, as brokers' returns.

Rev. a/c—Revenue account.

Reversion—The right to property after some particular event, such as the death of the holder.

Rider—An addition to a document after completion, or an additional clause to a resolution.

Rig—To rig a market is to force up the price of a security, and is usually done by buying up sufficient to create a scarcity.

Rigger—One who rigs a market.

Ring—A combination of financiers or capitalists to manipulate produce or securities and regulate the price.

R/p—Return of post.

Rs.—Rupees.

R.S.O.—Railway sub-office.

Rummage—To rummage a ship is for the Customs officers to search her for dutiable or prohibited articles when she is unloading. See Re-rummage.

Running Days—A chartering term for consecutive days, Sundays and holidays excepted, in which the cargo is to be loaded or discharged.

Running-down Clause—A clause in a marine insurance policy by which the underwriters agree to pay a proportion of damages assessed by a law court against a ship for injuring another vessel in collision.

Running Hours—Consecutive hours allowed for loading or unloading a ship.

Running of Goods—The secret landing of goods without paying legal duties. Such goods are said to be "run on shore."

Running Policy—In marine insurance, an open policy (which see) where the risk attaches to the goods on board during a period or up to a specified day.

Rupee Paper—Promissory notes of the Indian Government, payable in rupees.

$—Dollars or dollar.

S.A.—Subject to approval.

Sag—Prices "sag" when they fall away gradually.

Sale Note—A contract note sent by a merchant to a buyer specifying the quantity of goods sold, the price, and other particulars.

Sale Warrant—A warrant issued with a weight note when a deposit is paid on goods sold, and exchanged for the actual warrant for the goods when the balance is paid.

Salvage—An allowance paid to those who help to save a ship and its cargo from the perils of the sea; also goods so saved; and, thirdly, goods saved from a fire.

Salvage Loss—In marine insurance, the difference between the value of the property insured and that of the goods saved, plus charges, this difference being settled by the underwriters.

Sample—A small part of any merchandise shown as a specimen of the whole. A "fair average sample" is one made up of portions of different lots or portions selected from different places in one lot and bulked together.

Sampling Order—An order to a wharfinger authorising him to permit samples of goods in his wharf to be taken away by the bearer of the order.

Sans Frais—Without expense.

Sans Recours—"Without recourse to me." A phrase in the endorsement of a bill or note when the endorser wishes to free himself from responsibility.

S.B.—Sales Book.

s.c.—Sharp—that is, prompt—cash.

Scp.—Scrip.

S/D—Sea-damaged, used in grain trade.

Scrip—Short for "subscription." A receipt for money paid as instalments for shares in public companies, etc., and exchanged for a share certificate.

Sea Letter—Same as Ship's Passport, which see.

Searcher—A Customs officer who searches ships for contraband and dutiable goods.

Seconda Via—A second copy of a letter, sent independently to ensure arrival in case of the original miscarrying.

Second-class Paper—See Fine Paper.

Secured Creditor—A creditor who holds security, such as a mortgage, bill of sale, etc.

Seigniorage—The difference between the price paid for bullion and the face value of the money into which it is coined.

Seizin—The possession of an estate.

Seizure Note—A document used when smuggled goods are detected and seized by the Customs authorities. The note is filled in by the officer seizing the goods.

Seller's Option to Double—Put of more. See Options.

Sellers Over—A term for when there are more sellers than buyers.

Selling Out—When a buyer has not taken up his securities at the time agreed, the seller can sell the securities elsewhere, and charge the buyer with all the expenses to which he has been put. This is called selling out.

Sequestration—Placing a property in the hands of a person other than the owner, for one of three reasons: (1) When it is in dispute; (2) when the owner is bankrupt; (3) when the profits are needed to pay demands on it. The person to whom the estate is entrusted is called a sequestrator.

Set of Bills—Same as set of exchange.

Set-off—A counter-claim made against a person who is making a claim, as where parties are indebted to one another, when one debt is set off against the other and the balance only paid.

Set of Exchange—Three identical bills drawn at one time and forwarded by different routes, the acceptance or payment of the first to arrive cancelling the others. See also Sola Bill.

Settling Day—Same as Pay Day.

Settlement—On the Stock Exchange, the periods, occupying three days, and occurring twice a month, when shares are taken up and paid for or differences settled. The actual day on which the settlement takes place is called settling or pay day. The preceding day is "ticket day," when tickets pass between brokers and jobbers so that each may know what he has to deliver or receive on pay day. The day before ticket day is contango day, when the contango (which see) is fixed for bargains that are being continued.

Sh.—Share. See page 2984-5

Share Register—The register containing the names of persons holding shares in a limited company, and the extent of their holdings. Also called register of members. See page 2983

Shipbroker—An agent for a shipowner who obtains cargo, effects insurance, and attends to the general business of the ship.

Shipmaster—The captain of a ship.

Shipping Advice—An advice from a railway company declaring that they have forwarded goods to the docks for shipment on a certain vessel.

Shipping Bills—A Customs document used where drawback is claimed where dutiable goods are shipped for re-export or for ship's stores. Also a document giving details of a ship and goods for statistical use.

Shipping Notes—The receiving note and mate's receipt, which see. Shipping notes are always in these two parts.

Shipping Parcels Receipt—A document on which small packages of goods not exceeding £5 in value are generally shipped.

Shipping Specification—A form on which are supplied to the Customs particulars of goods shipped.

Shipping Weight—The specified weight of goods when put on board.

Ship's Certificate of Registry—A document giving the ship's name, tonnage, owner, master, etc., which shows that she is entered at the Custom House, and is entitled to enjoy the privileges of a British-built vessel.

Ship's Clearance—Permission by the Customs for a ship to unload (clearance inwards) or to sail (clearance outwards) when all the necessary formalities have been complied with.

Ship's Husband—An agent who looks after the management of a ship's affairs, attends to repairs, provides stores, etc., while she is in port.

Ship's Papers—The certificate of registry, manifest, licence, passport, muster roll, bill of health, log-book, articles, bills of lading, and, if there is one, charter party.

Ship's Passport—A document given to a neutral ship in war-time, authorising her to sail.

Ship's Protest—A declaration by the captain of a ship describing the circumstances in which injury to the ship or cargo occurred. The protest must be made immediately on arriving in port, and recorded by a notary public.

Ship's Report—A form that must be filled up by the master of a ship within twenty-four hours of arriving at any port in the United Kingdom, giving various particulars as to ship, cargo (if any), and crew.

Ship's Store Bond—A bond given to the Customs by the master of a ship when dutiable articles are to be taken on board as stores.

Ship's Stores—Articles such as food, drink, cigars, etc., that are required for crew and passengers on a voyage. In Customs documents it refers to those that are dutiable.

Short Bill—A bill of exchange payable on demand or having less than ten days to run.

Short Exchange—The rate of exchange for bills payable ten, twenty, thirty, or more days after sight.

Short Interest—In marine insurance, the amount over-insured, when the interest declared is less than the sum insured. The assured person can claim the return of premium on this amount. See also Over-insurance.

Short Loan—An advance made for a short period.

Short Money—Same as Short Loan.

Short of Stock—The American Stock Exchange term equivalent to the English "bear."

Short Shipment—Part of a consignment left behind, either by accident or because of lack of room in the ship.

Shut for Dividend—A term used when the transfer books of a bank or company are closed for the preparation of dividend warrants.

Shut Out—Term used when goods are left out of a ship owing to lateness or lack of room.

S.I.—Short interest.

Sight Bill—A bill of exchange payable at sight—that is, when presented.

Sight Entry—Same as Bill of Sight.

Signatories—Persons who sign a company's articles of association.

Signature Book—Book kept by a bank for the recognised signatures of depositors, so that in cases of doubt signatures may be verified.

Skipping—Customs term for temporary transferring of goods from one package to another for the purpose of taring.

S.L.—Sigilli Locus, the place for the seal on a document. Sometimes written L.S.

Sld.—Sailed.

Sleeping Partner—A person with money in a business, in the conduct of which he takes no active part. Called also dormant partner.

Sliding Scale—A scale fixing wages according to the rise and fall of price in the goods produced.

Slinging—A shipping charge for hoisting goods by chains from lighters to the ship.

Slip—In marine insurance, a piece of paper bearing the name of a ship, description of goods, and amount of insurance, signed by Lloyd's underwriters prior to policy being issued.

S/N—Shipping note.

S.O.—Seller's option.

S.O.D.—Seller's option to double.

Sola Bill—A bill of exchange of which only one copy is made. See also Set of Exchange.

Sold Note—A note with details of a sale sent to a buyer.

Solvency—The state of being solvent—that is, able to pay all one's debts in full. See Insolvent.

S.P.—Supra protest.

Special Endorsement—An endorsement on a bill of exchange stating the name of the person to whom it is transferred.

Special Settlement—Special days fixed by the Stock Exchange for the settlement of foreign loans, new issues, etc.

Specie—Coins, as distinguished from paper money or bullion.

Specie Point—The rate of exchange produced by the sale in one country of gold bought in another.

Spedition—Forwarding.

Spits—Rods of wood or metal used by Customs officers to insert in bales, etc., when searching for dutiable articles concealed.

Spot—Term used of goods actually on the spot, available immediately.

Stag—Stock Exchange term for a person who takes shares in a new company to sell directly they are at a premium

Stagging—The operations of a "stag."

Stale Cheque—A cheque that remains unpaid a long while.

Stamp Note—A Customs document giving permission for goods to be loaded on board ship.

Standard Gold—The gold of English coinage—22 parts of pure gold with 2 of alloy.

Standard Silver—The silver of English coinage—37 parts of pure silver with 3 of copper.

Statement—An account for goods owing, issued at regular intervals by a trader.

Station—Customs term for one or more warehouses.

Stem—To load a ship with coals within a certain period.

Sterling—A term used to distinguish English money.

Sterling Bonds—American railroad bonds payable here in English money.

Stet—Let it stand. Term used to indicate that a word or phrase crossed out is to remain as originally written.

Stiffening Order—A Customs permission for a ship to load heavy goods as ballast to steady her in the water, previous to permission for the general loading.

Stock—The national debt of a country; the share capital of a public company; an accumulation of goods.

Stock-jobber—See Jobber.

Stock Receipt—A receipt for the consideration money which the seller of stock gives, enabling the purchaser to have the stock registered in his own name.

Stop—A stop is put on a cheque, bill of exchange, banknote, etc., when it has been stolen or lost, by instructing the bank not to pay it if presented.

Stoppage in transitu—The stoppage of goods during transit. The consigner has the right to do this until the full price for the goods has been paid.

Stow—To pack merchandise in a ship so that it will not shift or get damaged on the voyage.

Stowage—The packing of cargo in a ship; also wages paid for stowing. See Dunnage.

Stranding—In marine insurance, the running of a ship on a rock, sandbank, or shore, and remaining there for a considerable time. Mere striking is not stranding, however great the damage.

Sub-lease—A lease by a lessee to another party.

Sufferance Wharf—A wharf licensed by the Customs for the landing and storing of dutiable goods.

Supra Protest—To sign a document or pay a sum supra protest is to do so under the impression that one is in danger of being wronged.

Survey Report—A document by an independent party stating what allowance should be made for goods that have been rejected on arrival owing to damage or other cause.

Suspected Bill—See Bill of Health.

Sworn Meter—In the grain trade, a document certifying particulars as to the quantity taken from a ship. It is signed by the discharging agents, and freight is charged on it.

T.—Tons.
Take in—To receive backwardation.
Take up—To pay for a thing, as to take up a bill of exchange when it is due, or to take up a bill of lading by paying the freight due.
Tale Quale—To take anything—a cargo of grain, for instance—as it is, with all faults.
Tallying—Checking another person's count.
Talon—A certificate attached to the coupon sheet of transferable bonds, which may be exchanged for a further series of coupons when the first is exhausted.
Tape Prices—Stock Exchange and market quotations recorded on the tape telegraph instrument.
Tare—An allowance for the package in which goods are sent. Real or actual tare is for the exact weight of the packing; average tare for the average weight of a number of similar packages; customary tare for the established usual weight allowed; estimated tare for the estimated weight of a package similar to others of known weight; super tare, an additional tare made where the package exceeds a certain weight.
T/C—Till countermanded.
Telegraphic Transfer—The payment of money to another country by a cable order.
Telegraph Restante—A term used where a telegram is to remain at the telegraph office till called for.
Tel quel—Same as Tale Quale.
Tender—An offer of money to pay a debt; also a written offer to buy or sell certain goods. See also Legal Tender.
Tenure—The manner of holding lands or buildings.
Term Days—The days on which rents fall due.
Terminable Annuities—Annuities sold by the Government for specified periods.
Term of a Bill—The time for which a bill of exchange is drawn.
Third-class Paper—See Fine Paper.
Ticket Day—See Settlement.
Time Bargains—Speculative Stock Exchange transactions for periods beyond the fortnightly settling-day.
Time Policy—A marine insurance policy for a specified period, and not for a voyage. No marine policy is good for more than twelve months.
T.L.O.—Total loss only (in marine insurance).
Token Money—Coins worth intrinsically less than their face value, like our silver and bronze money.
Tonnage Dues—A charge of so much per ton on a ship's registered tonnage, upon her entering or leaving a port.
Tontine—A scheme by which a number of persons buy a life annuity for each. As each dies, his share is divided among the others, until the last survivor eventually enjoys the whole.
Towage—Charge for towing a ship.
T/q—Tale quale.
T/R.—Tons registered (shipping).
Tr.—Tare.
Trade Rights—Proprietary rights, other than brands or trade marks, belonging exclusively to a firm that has built up a business.
Transfer Days—Fixed days at the Bank of England, etc., for registering transfers of stock.
Transires—Duplicate accounts on prescribed forms, giving full details of a ship's cargo, with names of both shipper and consignee. The duplicate, given up to the Customs, clears the boat outwards; and the original, given up at the destination, is the ship's entry inwards.
Treasury Bills—Bills issued at a discount by the Treasury in return for money lent to the Government. They bear no interest.
Tret—An allowance sometimes made on goods for waste, dust, etc.
Trim—To ballast a boat so as to steady her; also to stow coal or other bulk cargo so that it is distributed evenly.
Trinity House—The institution that regulates the marine interests of the United Kingdom, erecting lighthouses, appointing pilots, conducting mariners' examinations, etc.
Truck—Paying wages in goods instead of money.
Trust—A large combination of capitalists to conduct a business.
Trustees in Bankruptcy—Persons appointed by the Court to manage a bankrupt's estate during liquidation.
T.t.—Telegraphic transfer.
Turn—The profit which a stock-jobber makes on a transaction with a broker.
Turnover—The total amount of goods sold over a given period.
Type—A standard sample of produce, such as corn, rice, sugar.

ULLAGE—The difference between the capacity of a cask, or other vessel, and the quantity it actually contains; also the waste in casks, etc., from leakage, evaporation, and similar causes. An ullaged cask is one that has lost some of its contents.
Ult., Ultimo., Ulto.—The last month, used in correspondence when referring to dates.
Ultra Vires—When a company, etc., exceeds the authority granted by law, it acts "ultra vires."
UN—Unified.
Uncalled Capital—The difference between the subscribed capital and the called-up capital of a company.
Under Bond—Dutiable goods, when removed from place to place, are "under bond" to pay the duty if not produced at their destination.
Under Protest—See Supra Protest.
Underwriter—A marine insurer, so called from his signature under each policy.
Underwriting—In company work, guaranteeing that the capital of a new company shall be subscribed.
Unfunded Debt—Loans, represented by Exchequer and Treasury bills and bonds, borrowed for short periods, which the Government is bound to pay at specified dates.
Unified Stock—Several loans at different interest amalgamated into a common debt at a fixed interest.
Unlimited Company—A company whose shareholders' liability is not limited to the amount of their shares.
Unmerchantable—Goods unsound or below standard.
Usance—The period allowed between two places for the currency of foreign bills of exchange.
Usufruct—The right to use anything belonging to another, and acquire the profit or benefit resulting, but without diminishing its substance.
U/w—Underwriter.

VALUE—Face value is the sum printed on the face of notes and securities. Nominal value means the nearest price named without business passing.
Valued Policy—A marine insurance policy in which the amount insured is valued or fixed.
Value in Account—A term used in bills of exchange when the drawer has a commission or balance to draw from the drawee.
Value Received—Term used in bills of exchange when the drawee has received money or goods from the drawer.
Value Upon—To draw a bill upon.
Vatting—Customs term for mixing various wines or spirits in a large vessel to obtain uniformity.
Vendor's Shares—Shares taken in lieu of cash by a person transforming his business into a company.
Vendue—A public auction.
Venture—Goods shipped at the sender's risk for sale at the place of destination.
Via—The copy of a document sent by a different route from that of the original, so as to replace the latter if it goes astray.
Victualling Bill—A list of dutiable goods taken on board ship for use as stores, given to the Customs by the captain.
Voucher—A written document giving proof of a money transaction.
Voyage Policy—A marine insurance policy insuring a ship or cargo for a certain voyage.

WAGER POLICY—A policy on which there is no real interest at risk, and the underwriters do not require the usual documents to prove a loss.
Waiver Clause—A clause in marine insurance which declares that no acts of insurer or insured in recovering, saving, or preserving the property insured shall be considered as an acceptance of abandonment.
Wall Street—The New York Stock Exchange.
Warrant—A receipt for goods deposited in a warehouse, and transferable by indorsement. Must bear 3d. stamp.
Warranty—In marine insurance, a condition which, if not complied with, vitiates the contract.
Watering Stock—Increasing capital by creating new stock without corresponding provision for paying dividends.
W.B.—Way-bill; warehouse book.
w.b.—Water ballast.
Wd.—Warranted.
Weight Note—A document issued by a dock company giving gross weight, tare and net weight, marks, numbers, and date of entry of imported merchandise.
W.I.D.—West India Docks.
Wind Bill—Same as Accommodation Bill.
Window-dressing—Money-market term for the swelling of a bank's cash balance in the monthly statement by calling in loans, etc.
Without Engagement—A term used when quoting goods liable to fluctuation, and implying that the merchant does not bind himself to accept an order at the price.
Without Recourse—A term often used on a bill of exchange, implying that the buyer has no recourse on the seller if the bill is not paid when due.
W.O.B.—Washing overboard (marine insurance).
W.P.—Without prejudice.
W/W—Warehouse warrant.

X.c.—Ex coupon.
X.d.—Ex dividend.
X.in.—Ex interest.
X.new—Ex new.

Y/A—York-Antwerp Rules.
York-Antwerp Rules—In marine insurance this term means that both parties agree that in case of general average the adjustment shall be made according to the rules of the Underwriters' Conference at Antwerp in 1877.

ZOLLVEREIN—A Customs union between various States.

#—Numbered, as # 1/30.

PRIME MOVERS & STEAM BOILERS

ACTUAL HORSE-POWER—Horse-power obtained by the indicator, minus the power absorbed by the engine friction.

Adhesion—Specifically, the measure of the weight resting on the wheels of locomotives.

Air Pump—A pump employed in all condensing engines for removing the mixed air and water from the condenser.

Asbestos—A fibrous mineral, which, owing to its heat-resisting character, is prepared for use in engine packings and joints.

Atmospheric Engine—An early type, in which the pressure of the air moved the piston downwards against a partial vacuum.

Atmospheric Line—The line on an indicator diagram which divides the steam area from that of vacuum.

BACK PRESSURE—Pressure opposed to the movement of the piston in a cylinder, due to steam not wholly exhausted.

Balloon Boiler, or Haystack Boiler—An obsolete form, of a dome shape, externally fired.

Barring Engine—A small engine used for starting a very large engine.

Beam Engine—A vertical engine having the piston-rod operating one end of a pivoted beam, and the connecting rod at the other.

Bed Plate—The base, usually a casting, which carries all the mechanism of an engine.

Blast Pipe—In a loco. boiler, the pipe through which the steam exhausts into the chimney, so creating a sharp draught in the fire-box.

Blow-off—The periodical discharge of steam, water, and sediment from a boiler.

Boilers—The steam generators for engines. Internal combustion engines require no boilers.

Brake Horse-power—Horse-power as measured by a friction brake.

CALORIE—The French unit of heat, or that which will raise 1 kilo. of water through 1° C. between the temperatures of 0° C. and 1° C.

Carnot's Principle—Postulates the law that the work done by a heat engine is wholly a question of temperature.

Central Valve Engine—An engine in which the distribution of steam is effected by openings in the piston-rods.

Cheval-Vapeur—French horse-power, or 4,500 kilogrammes lifted 1 metre high per minute, equals 0·9863 English horse-power.

Chimney—The function of a chimney is to produce a draught in the furnaces and flues of a boiler. It acts by virtue of the difference in the specific gravities of the hot air within and the cold air without.

Circulating Pump—A pump which forces the cooling water through the tubes of surface condensers.

Clark's Process—The best known process for softening the feed-water for boilers by the addition of lime thereto.

Clearance—The space left between the face of a piston at the termination of its stroke and the inner face of the cover, to prevent actual contact. Freedom to exhaust in an engine cylinder.

Clinkering—Cleaning the grate bars of boilers periodically.

Closed Ashpit—Signifies that the ashpit alone receives air under pressure.

Closed Stokehold—The stokehold enclosing the boiler front of a marine engine which receives the supplies of air through fans only.

Cold-water Test—The hydraulic pressure test applied to steam boilers with cold water.

Compound Engine—An engine having two or more cylinders in which steam works expansively in succession.

Condenser—The vessel in which the exhaust steam from an engine or engines is condensed to water.

Condensing Engine—One in which the exhaust steam goes into a condenser instead of into the atmosphere.

Connecting Rod—The rod which connects the piston and its cross head to the crank of the flywheel shaft.

Corliss Engine—One in which separate valves are used for the entering and exhausting steam.

Cornish Boiler—A horizontal boiler with a single furnace flue.

Cornish Engine—A special type of beam engine, used first in the Cornish mines.

Corrugated Furnace—A type of boiler furnace which is stiffened against collapse by alternating ridges and depressions.

Crank-pin—The pivot on which the free end of the connecting rod takes its bearing, being the end opposite to the crank shaft.

Cushioning—The elastic counter-pressure against a piston, bringing it to rest by the steam admitted through the opening to lead.

Cut-Off—Arresting the supply of steam to the interior of a cylinder.

Cut-off Valve—A supplementary slide valve on the back of a main valve for working steam at high expansion.

Cylinder—Specifically the vessel in which the movements of an engine piston are coerced.

DAMPERS—Sliding, or swivelling plates which regulate the draught through boiler flues.

Dead Centres—When the axis of the piston-rod, the crank-pin, and the crank-shaft are in one plane the engine is on dead centres.

Dead-weight Safety Valve—One in which the loading is done directly by the imposition of annular weights.

Double Acting—Expresses the case of pistons which are subjected to pressure on opposite sides alternately.

Dry Steam—Steam which is only saturated with moisture by contact with the water from which it is generated.

Duty—The duty of an engine is the number of foot pounds obtained by the burning of a bushel of good coal. The term is nearly obsolete.

D-valve—The form of slide valve which has a section nearly like that of the letter D.

Dynamometer—A mechanism by which the power given off or absorbed by a prime mover or machine is measured.

ECCENTRIC—The agent by which the rotary motion of the crank is converted into the reciprocating movement of the slide valve.

Eccentric Sheave—The body of an eccentric, keyed on the crank-shaft.

Eccentric Straps—The bands which encircle the sheave, and transmit its motion to the eccentric rods and slide valve.

Economiser—A nest of pipes in which the feed-water for boilers is heated by the waste gases from the boiler.

Elastic Force—The expansive, or heat energy of a gas.

Enclosed-type Engine—Stationary engines having the working parts wholly enclosed, and running in an oil bath.

Evaporative Power—It is usual to estimate the value of different fuels by the relative quantities of water which they will evaporate.

Exhaust Steam—The waste steam from an engine cylinder.

Expansive Working—A definite volume of steam or gas doing work on a piston by the force of its own expansion.

External Firing—The application of heat outside a boiler shell. Now obsolete.

FEED PUMP—The pump which supplies feed-water to boilers.

Feed-water Heater—A type of economiser in which the feed is heated before being passed into the boiler.

Ferrules—Rings used for fastening the tubes of boilers and condensers into their plates.

Final Pressure—The pressure of steam in a cylinder in the last stage of its expansion.

Fire-bars—The grate bars in a boiler furnace.

Fire-box—The furnace of a locomotive or a vertical boiler.

Forced Draught—Air for combustion in steam boilers which is introduced under pressure by fans.

Furnace Flues—The furnaces of horizontal boilers, placed within the shell.

Fusible Plug—A plug of easily fusible alloy, inserted in the top of a boiler furnace, which melts and lets the water out if the water runs dangerously low.

GAS ENGINE—Any engine using gas, which may be town, or producer, or blast-furnace gas.

Gaskets—Packings of hemp rope used in stuffing boxes.

Gauges—Instruments for indicating pressure of steam, and vacuum, and water levels.

Governor—A device which automatically reduces variations in speeds of prime movers.

Grate Area—The superficial area of the fire-grate of a boiler.

Guides—Flat bars, or cylindrical tubes by which the movements of the crosshead are coerced.

HEAT ENGINE—Any prime mover which is actuated by heat contained in a gaseous fluid.

Heating Surface—The area of a steam boiler which is exposed to flame and hot gases on one side and water on the other.

High-pressure Engine—Any engine which uses steam at a pressure higher than the ordinary at a given period. The high pressures of a few years ago would not be classed as such now.

High-speed Engine—One which has a high rotative or a high piston speed in comparison with ordinary engines. The term is therefore relative.

Horse-power, or H.P.—33,000 lb. lifted 1 ft. high per minute.

Hot-air Engine—One in which atmospheric air is used, which is alternately heated and cooled.

Hot-water Test—The hydraulic pressure test applied with hot water to steam boilers.

Hydraulic Engine—One, the motive-power of which is water under high pressure.

INDICATED HORSE-POWER, or I.H.P.—The horse-power of an engine obtained by an indicator.

Indicator—An instrument for recording on a card the varying pressures of steam in a cylinder.

Indicator Diagram—The diagram traced by an indicator.

Induced Draught—Boiler draught induced by a fan placed in or near the chimney in the course of the flues.

Induction Port—The opening of the passage through which steam is admitted to a cylinder.

Ignition—The act of firing the charge in the cylinder of a gas engine.

Injector—A device for supplying feed-water to a boiler.

Internally Fired Boiler—One which has its furnace within the shell or water casing.

JACKETING—Surrounding an engine cylinder with a chamber supplied with steam.

LANCASHIRE BOILER — A two-flued horizontal land boiler.

Lap—The distance by which the edges of a slide valve when in middle travel overlaps the induction ports.

Latent Heat—The heat which disappears during the vaporisation or the fusion of a substance, without raising the temperature.

Lead—The distance by which the edge of a slide valve opens the exhaust port at the termination of the piston stroke.

Liner—The lining tube of hard metal fitted within many engine cylinders.

Link Motion—The arrangements of slot link, eccentrics, and rods used for actuating the movements of slide valves.

Live Steam—Steam as it comes from the boiler.

Lubricators—Vessels which contain liquid or solid lubricants for the supply of bearings.

MAIN BEARINGS—The bearings of the crank shafts of engines.

Mean Pressure—The average of the entire range of steam pressures in a cylinder from the moment of inlet to that of final exhaust.

Metallic Packings—The steam-tight joints made in stuffing boxes with elastic rings of metal.

NEWCOMEN'S ENGINE—The pattern on which the early steam engines were built. It was operated by atmospheric pressure.

Nominal Horse-power (N.H.P.)—A commercial term, a survival of an early practice, of little value under changed conditions.

Notching-up—In link motions, pulling the link nearer to the centre, with resulting earlier cut-off and higher expansion.

OSCILLATING ENGINE—A nearly obsolete type, in which the oscillation of the cylinder was made to operate the slide valves.

PACKINGS—Materials used in stuffing boxes for rendering piston and valve rods steam-tight in their holes.

Piston Speed—The speed of movement of a piston measured in feet per minute.

Piston Valve—A sliding valve which is of cylindrical section.

Prime Mover—A machine which utilises the forces of Nature for the service of man.

Priming—The mixing of particles of water with steam.

Producer Gas—Gaseous fuel generated by the combustion of solid fuel in gas producers of various kinds.

QUADRUPLE EXPANSION ENGINE—One in which the steam is expanded through four successive cylinders before exhausting to the condenser.

RECEIVER—The steam chest, pipe, or special vessel through which steam passes from one cylinder to the next in compound engines.

Return Tube Boiler—The marine, or Scotch boiler, in which the smoke tubes return over the top of the furnace to the front of the boiler.

Reversing Rolling Mill-engine—A special design used for rolling steel plates and sections, the direction of movement being reversed between each pass.

Right-hand Engine—One in which the flywheel stands to the right, when viewed from the front of the engine.

SAFETY VALVE—A valve on a boiler which opens when a definite steam pressure is exceeded, so relieving the steam pressure.

Saturated Steam—Steam in contact with water of the same temperature.

Scale—Deposit which hardens on the water side of the plates of steam boilers.

Setting of Boilers—Fixing land boilers over their flues, and seatings of brickwork.

Slide Valves—Valves occurring in numerous forms, the function of which is to control the supplies of steam to cylinders, as distinguished from lift or drop valves and rotating valves.

Slipper—Slipper bars are guide bars; a slipper block is a piston crosshead.

Slot Link—The link through which variable expansion, and reversals are effected.

Smoke—Particles of solid carbon suspended in unburnt gases, and vapour of water. Its proper combustion is the object of many devices in boiler engineering.

Soda—Used for preventing scale in boilers.

Split Draught—The arrangement of flues in Lancashire boilers in which the products of combustion are divided at the back, and pass round to right and left.

Stationary Engine—One fastened to foundations.

Steam—The vapour of water, which, by virtue of its elastic energy, communicates motion to a piston or rotor.

Steam Chest—see *valve chest.*

Superheated Steam—Steam made hotter than the temperature at which it is generated.

Surface Condenser—One fitted with tubes in the steam space, and through which the cold water circulates. It differs in this respect from the jet condenser, which receives one jet of water.

TAIL ROD—A rod in continuation of a piston, or valve rod, but on the opposite side. Its function is to steady the movements of the piston, or valve.

Tandem Engine—A compound engine, the cylinders of which are in the same longitudinal axis.

Thermal Unit—The amount of heat required to raise 1 lb. of water 1° F. is the British Thermal unit, and is equivalent to 772 foot-pounds.

Three-cylinder Engine—Specifically an engine in which the cylinders are arranged round a circle, with their axes 120° apart.

Throttle Valve—A valve which opens and closes the supply of steam from a boiler to an engine.

Throw—Twice the radius of an eccentric or a crank.

Tractive Force—The power exercised by the pistons and driving wheels of a locomotive to move a train.

Travel—The length of movement of a piston or a valve.

Triple-expansion Engine—One in which the steam is expanded from one high-pressure into two low-pressure cylinders in succession.

Trip Lever—A lever which lifts drop valves through a certain distance, and then allows them to close sharply.

Try Cocks—The steam and water-cocks on a boiler which indicate the highest and lowest water level allowable.

Tube Expander—An appliance used for tightening the fire-tubes in multi-tubular boilers.

Tubes—Tubes of brass, steel, iron, or copper are used in boilers to convey the heat from the fire-box through the water to the smoke-box.

Tube Surface—The total area of the exterior surfaces of condenser tubes.

Tubular Boiler—Any boiler provided with nests of tubes to increase the heating surface.

UNDERTYPE ENGINE — A fixed engine with a locomotive type of boiler, in which the engine is fixed beneath the boiler.

Unit—A standard for calculations—as the unit of heat, of work, of mass, of strength, or of stress.

VACUUM—The amount by which the pressure of a condenser is below that of the atmosphere. It is measured in pounds, or in inches of mercury.

Valve—The agent by which the opening of steam and exhaust passages is controlled. It may be a slide valve, flat, or of piston type, or a drop, or a partly rotating valve. Or a main, or a cut-off valve.

Valve Chest or Steam Chest—The casing which encloses a slide valve.

Valve Diagrams—Diagrams made to show graphically the cycle of action of valves.

Valve Setting—Adjusting valves in relation to the crankpin and the eccentric sheave.

Variable Expansion—The expansion of steam in a cylinder caused by alterations in the opening of the throttle, or in the point of cut-off of the valves.

Varying Travel—The travel of a slide valve which is varied momentarily by expansion gear, instead of being constant by a fixed eccentric only.

Vertical Boiler—A cylindrical boiler having its axis set vertically.

Vertical Engine—An engine having the axis of its cylinder set vertically.

WAGGON BOILER—An obsolete form, deriving its name from its cross section. It was externally fired.

Wall Engine—A steam engine, the bed-plate of which is bolted to a factory wall, the axis of the engine being vertical.

Waste Heat—Residual heat from furnaces which, formerly lost, is now frequently utilised in warming feed water, or brickwork, or air and gas.

Water Pressure Engines—Engines of rotary or reciprocating types which are operated by water under pressure.

Water-tube Boiler—A steam boiler in which the fire plays around nests of small water-tubes variously arranged.

Weight Shaft—The shaft which carries the lever for lifting and lowering the slot links of valve gears.

Wheel Draught—The arrangement of flues in Lancashire boilers, in which the products of combustion pass round the boiler in one direction.

Winding Engine—A hoisting engine designed specially for hauling mine waggons up inclines.

Windmill—A wind engine, the chief use of which now is to drive well pumps in country districts.

Wire Drawing—Steam is wire-drawn when passages are made too small to permit it to enter with freedom into the cylinder.

Wire Gauze—Finely-woven wire used for making steam-tight joints between flanges.

Woolf Engine—An early compound engine in which the crank-pins were set 180° apart.

Wrist Plate—The rocking disc which transmits motion to the valve spindles of Corliss engines.

THE BUILDING TRADES

BUILDING CONSTRUCTION

ABUTMENT—The solid part of a pier from which an arch springs directly.
Ancient light—An opening for the admission of light and air that has, by prescription, obtained a legal right to such easement in perpetuity.
Angle of repose—The natural angle at which any given material will remain at rest.
Annulet—A fillet or band circular on plan.
Applied ornament — Ornament attached to the surface, not worked on the solid.
Area—An enclosed court or yard. A sunk space arranged for lighting or for access to a floor below the ground level.
Arris—The line formed at an exterior angle by two intersecting surfaces.
Aspect—The quarter of the heavens which any front or opening of a building faces.
Astragal—A small moulding semi-circular in profile.
Attend upon—A term indicating the assistance to be given to each tradesman by other trades.
Attic story—A story formed wholly or partly in a roof.

BALCONETTE—A small balcony.
Barrel roof—A roof of which the soffit is semi-cylindrical.
Base—The foot or lowest portion of any part of a building.
Basement—The story of a building below the principal or ground floor.
Bay—The subdivision longitudinally of a building by piers, arches, girders, etc.
Beam—A piece of timber or iron placed horizontally—generally over a void.
Beam compass—An instrument for drawing large circles composed of a lath and adjustable slides carrying the point and pen and pencil.
Bearing—The area of support to the end of a joist or beam. Also used to denote the clear distance intervening between such points.
Bed—The horizontal surface on which stones, bricks, and other substances used in building rest. In arches the bearing surface on each side of a voussoir.
Bed mould—A moulding immediately below and apparently supporting an overhanging surface.
Bevel—The slope formed by cutting off a right-angled arris by a plane intersecting both original planes.
Block plan—A plan showing a site on which only the outline of buildings is indicated.
Boning—The act of making or judging a plane surface or line by the eye.
Break—The recess or projection of one piece of work behind or in front of the remainder.
Bullnose—A rounded junction between two surfaces enclosing an angle.
Buttress—A mass of masonry or brickwork so disposed as to counteract the thrust exerted by an arch or vault.

CAMBER—A slight convexity to counteract deflection due to load.
Camp-sheeting—A timber retaining-wall to prevent erosion in rivers and canals.
Cant—Any part of a structure formed at an angle other than a right angle.
Cantilever—A beam, bearer, or girder, one end of which is free and the other fixed.
Cap—The crowning member of a pier or column.
Capping—A moulding or group of mouldings on the top of a dado, screen, or gate.
Carcase—The structure of a building before finishings are added.
Castellated—Terminated with battlements.
Catch-pit—A pit formed to collect fluid or solid matter.
Caulking—The stopping of open joints.
Chamfer—See *Bevel*.
Channel—A long sinking formed in the ground or on the surface of any material.
Chisel-pointed — With a flat, broad point.
Cinquefoil—A form of enrichment having five cusps.
Circle on Circle Work—Work circular in elevation as well as on plan.
Clearstory or **Clerestorey**—A range of windows placed high up in a hall or church.
Clear, In the—The net distance between any two points or surfaces.
Clear span—See *Bearing*.
Clerk of Works—An individual appointed to superintend building operations on behalf of the architect.
Coffer—A sunk panel in a ceiling or soffit.
Coin or **Quoin**—The external angle formed by the junction of two walls.
Collar—A ring of metal or other material placed round any object.
Colonnade—A range of columns.
Column—A vertical circular support.
Concavity—The hollow side of a curved line or other object.
Concentric—Circular figures or portions of circles struck from a common centre.
Conduit—A term applied to a channel or pipe used for the conveyance of fluids.
Console—An ornamental bracket used to give real or apparent support to a cornice or other feature.
Convex—The swelling side of a curved line or other object.
Contrary flexure—A curve, part of which is convex and part concave.
Corbel—A projection from a wall to carry any overhanging portion.
Core—The interior, heart, or centre of any object.
Cornice—A group of mouldings crowning a wall or other surface.
Corona—A broad vertical face in a cornice with an overhanging soffit.
Countersinking—A sinking formed in timber or other material to receive the head of a screw or bolt that it may be flush with or below the surface.
Cove—A large hollow moulding generally formed in the cornice of a ceiling.
Crank—A rigid arm fixed at the end of a shaft perpendicular to its axis.
Cresting—An ornamental finishing to a ridge or parapet.
Crib—A stable rack.
Crown—The highest part of an arch or vault.
Crushing Load—The load under which any material loses its power of cohesion.
Culvert—A circular underground channel for conveying fluid.
Cupola—A spherical roof or dome.
Cusps—The points between the foils of a foliated arch.

DADO—The central feature of the pedestal of a column, or a deep band, usually with base and capping at the base of a wall.
Dead load—A permanent load, one which does not move.
Dead shore—A vertical timber strut receiving a dead load only.
Dentils—Square blocks carved out of a projecting fillet.
Detrusion—An outward thrust tending to separate one body from another. A shearing strain acting parallel to the fibres of a material.
Die—Another term for dado. Also a mould from which objects in relief may be struck.
Dome—A convex roof over a circular or polygonal building.
Dominant tenement—In the case of an easement the tenement to which the privilege belongs.
Dormer—A window placed on the inclined plane of a roof the front of which is vertical.
Dressings—Brickwork, terra-cotta or masonry finishings of a superior quality introduced into rougher walling.
Drum—A vertical, circular, or polygonal wall carrying a cupola or the blocks of material composing the shaft of a column.

EAVES—The lowest edges of the inclined sides of a roof projecting beyond the walls.
Elastic limit of any material—The greatest strain that does not produce a permanent set.
Elevation—A geometrical projection representing the outer surface of an object on a perpendicular plane.
Embossing—The raising or forming of any form or design above the surrounding surface.
Engraving—The cutting in or sinking of any form or design below the surrounding surface.
Enriched mouldings are those whose profile is treated with ornament.
Entering angle—The internal angle formed by the intersection of adjacent surfaces.
Entresol—A room formed above another in the general height of a lofty story.
Estimate—The computed cost of any work.

FABRIC—A term applied to the structural portions of buildings.
Façade—The face or front of any building.
False bearing—A column or wall bearing on the unsupported part of a girder.
Fan—An apparatus for mechanically changing or moving air. A hoarding projecting outwards during pulling down.
Fatigue of material—The failure of material under a recurring load which produces a stress exceeding its elastic limit.
Feather edge—A term applied to any thin body having one edge thicker than the other.
Fillet—A narrow flat band.
Finial—The ornamental finishing of a pinnacle, gable, or turret.
Finishings—The various works to complete a building after the shell has been erected.
First floor—The story next above the ground floor, so also with second floor, third floor, etc.
Fixture—An article of a personal nature affixed to land or buildings, whether movable or not.
Flange—A plate projecting from the side or end of a piece of wrought or cast metal.
Flank—The return or side part of a body which joins the front and rear.
Flush—A term signifying the continuity of surface of two bodies joined together.
Flutes—Channels on a vertical shaft.
Foil—The small arcs used in tracery to enrich a larger curve.
Foliated—The use of foils in tracery.
Foundation—The basis, natural or artificial, upon which a superstructure is raised.
Frieze—A broad band, ornamental or otherwise, immediately below a cornice.

GABLE—The vertical triangular end of a sloping roof.
Gablet—A similar feature used as an ornament in buttresses.
Gangway—An open passage-way, temporary or fixed.
Girder—A beam used to support a load over a void.
Girt or Girth—The length of the circumference or profile of an object.
Gradient—The vertical rise in a path or road compared with its length.
Grille—An enclosure formed of crossed bars.
Ground plan—The plan of a building taken at the ground floor level.
Guides—Grooves in which a sliding door or shutter runs.

HALF-LANDING—An intermediate landing in a staircase, extending right across the well-hole.
Half-timber—A structure framed of large timbers, the panels filled in with brick or plaster.
Head-room—The space above a flight of stairs necessary to allow free passage.
Herring-bone work—Blocks of material laid diagonally, the end of each butting against the side of the next block.
Hipped-roof—One in which adjacent sides are inclined and form salient angles.
Hood—A projection to protect an object beneath it from the action of the weather.
Housebreaker—A contractor who pulls down existing buildings and clears away the materials.

IMPOST—The capping of a pier or pilaster that receives an arch.
Incrustation—Material, usually decorative, applied by some connecting medium to another body; or a deposit caused by chemical decomposition.
Inlaid work—Work of which the surface is partly cut away and filled in with other materials.
Intaglio—Ornament sunk below the general surface of a piece of work.
Inverted arch—An arch formed below instead of above its springing line.

JACK—A machine used in building operations to move heavy loads.
Jamb—The vertical sides of an opening in a wall.

KILN—A structure in which materials are calcined or burnt.

LABEL—A projecting drip moulding around an aperture.
Landing—The floor terminating a flight of stairs.
Lateral thrust—The outward force exerted by an arched or framed structure.
Lattice—Open work made by crossing strips of iron or wood.
Level—An instrument used by the carpenter and mason to indicate when a line or surface is parallel with the horizon. (See also **Surveying.**)
Live load—A load consisting of bodies subject to motion.
Loose box—An enclosure within a stable in which a horse can be left loose.

MALLEABLE—Material susceptible of extension under the blows of a hammer.
Market sizes—The sizes in which timber and other materials are stocked and sold.
Mezzanine—A story of small height between two higher ones.
Mitre—A plain joint between two similar pieces of material or mouldings bisecting the angle at which they meet.
Mosaic—An incrustation formed with small cubes of marble, stone, glass, etc.
Moulds—Patterns or contours from which work is wrought. A prepared case into which certain fluid materials are introduced to set or cool, or in which plastic materials are given definite forms.
Mouldings—The ornamental contours given to the projecting or receding edges of materials.

NECKING—Any small moulding near the top of a column or pilaster.
Neutral axis—The plane in a beam at which the stresses change, the effect of the stresses being nothing.

ORIEL—A window similar to a bay corbelled out on an upper story.
Out of winding—Material the surface of which is true and free from twist.
Out to out—A dimension taken to the extreme limits of any body or material.

PANEL—A surface enclosed by a frame and sunk below it; an imitation of such a feature in solid material.
Party wall—A wall used for separating adjoining buildings belonging to different owners.
Party fence wall—A wall standing on lands of adjoining owners as a separation of adjoining lands.
Pedestal—A short pier with base and capping under a column or statue.
Pendant—An ornament suspended below the main part of a structure.
Pendentive—The triangular portion of a truncated hemisphere formed by cutting it with two vertical planes each making an angle of 45° on plan with the end of its lower diameter.
Penstock—A small paddle working in a grooved frame for penning back water.
Penthouse—A shed having a lean-to roof.
Permanent set—A permanent change of form produced in an object due to straining the material beyond its elastic limit.
Piecework—Work paid for by the piece or job—not by time.
Plan—The representation to scale of any horizontal section of an object.
Plinth—A square projecting member at the base of a wall or below a moulded base.
Plotting—The process of laying down on paper to scale the plan, elevation, and section from measurements of an existing building or piece of land.
Plumb—Vertical.
Profile—The actual outline of any moulding or other body as shown by a plane drawn perpendicular to its surface.

QUADRANGLE—A square or rectangular court, generally within a building.
Quarter space landing—A landing in the angle between two flights of stairs making a right angle.

RACKING—The tendency to distort a piece of framing diagonally.
Raking—A member inclined at an angle with the horizontal.
Rampant arch—One whose abutments or springings are at different levels.
Re-entering angle—An angle the plan of which is sunk or returned as opposed to a solid angle.
Relievo or relief—Ornament raised above the surface of a piece of work.
Respond—The abutment of the last arch of an arcade.
Return—The continuation of a surface or moulding round an angle.

SAFE load—The permanent load any material or structure will safely support.
Salient angle—The external angle formed by the intersection of adjacent surfaces.
Scale—A line bearing some definite relation to the full size of an object and subdivided for the purpose of plotting.
Scantling—The dimensions of breadth and thickness in a piece of timber; and of length, breadth and thickness of a stone.
Seating—A carefully prepared bed for some object to rest on.
Section—A geometrical representation of an object or building divided by a vertical plane.
Servient tenement—In the case of an easement the tenement on which the obligation is imposed.
Setting-out rod—A board or boarded surface on which work is set out full size.
Settlements—Failures due to the unequal sinking of parts of a building.
Shoring—Temporary timber supports to a building during alterations or when it shows signs of failure.
Site—The plot of ground on which a structure is to stand.
Soffit—The under surface of a vault, arch, or horizontal member.
Span—The clear distance between the supports of a beam or arch.
Specification—A detailed description of the materials and workmanship to be used for any structure.
Spiral stair—One consisting entirely of winders.
Splay—The inclination of one side of an object obliquely to the adjoining side.
Stop—The finish to a moulding or chamfer.
Story—A complete stage in a building extending from one floor to the next.
Superstructure—The upper part of a building carried in the foundations.

TEMPLATE—A metal mould used for cutting masonry and by plasterers in sticking mouldings.
Tie—A member uniting two bodies having a tendency to diverge.
Tobin ventilator—A tube for introducing external air into a room at a suitable level.
Trammel—An instrument for describing an ellipse.
Transepts—The transverse portions of a cruciform building.
Transom—An intermediate horizontal member of a frame.
Trefoil—An ornament having three cusps.
Turret—A small tower often placed at the angle of a wall.

UNDERPINNING—Temporarily supporting a structure with dead shores; extending an existing wall to a greater depth with new foundations.

VALLEY—The internal angle formed by the meeting of two adjacent sides of a sloping roof.
Vault—The arched roof over an apartment; applied also to a vaulted cellar.
Verandah—A light external open gallery attached to a house, and with a sloping roof.
Verges—The edges of the covering of a roof projecting over a gable-end.

WAGON-HEAD VAULT—A cylindrical vault slightly stilted.
Weathering—The covering or special form given to the upper surface of walls or projections on a building to throw off water falling on it.
Well-hole—The open space in a staircase around which the flights are formed; an opening in a floor below a skylight.
Wings—The side portions of a façade or building subordinate to the principal and central portions.
Working drawings—Drawings showing details of a design and serving as instructions to the several artificers.

EXCAVATING, TIMBERING, SHORING, DRAIN-LAYING

AGRICULTURAL DRAIN—A drain conveying surface water from land.
Asphalte—A natural bituminous substance impervious to water.

BALLAST—Sandy gravel dredged from river beds used for concrete.
Ballast, burnt—Clay dug from excavations and burnt in its natural state.
Barrel drain—One in the form of a hollow cylinder.
Bends—Channels or pipes curved on plan.

CEMENT—A material used for binding together other material and capable of setting without the access of air.
Cement concrete, and mortar—Concrete or mortar the matrix of which consists of cement.
Centre—Temporary frame of wood on which an arch or vault is constructed.
Cesspool—A well formed below the ground to receive sewage.
Chair—Support used in drain laying to raise pipes above concrete bed.
Channel pipe—Pipe of half round section.
Clamp—Rectangular mass of crude bricks stacked for burning.
Clay puddle—Clay tempered with water.
Cleaning eye—An opening in a pipe through which it may be cleansed.
Cleat—Block of timber fixed to any timber to support a strut.
Clinker—A small vitrified brick used for paving.
Coffer dam—A temporary water-tight wall of timber and clay puddle to keep out water during building operations close by.
Concrete—A compound formed of various hard dry materials mixed with lime or cement and water which sets into a solid mass.
Crane—Machine for raising and shifting heavy weights.

DEAD SHORE—Vertical shore carrying a dead load.
Derrick—Form of crane often raised to and used at a great height from the ground.
Derrick stage—Form of gantry to support an elevated derrick.
Disconnecting chamber—Chamber formed in the length of a drain in which the house drain is disconnected from a sewer.
Dog-iron—Iron bar with ends sharpened and bent to right angles for holding together heavy timbers.
Drain—Pipe for the conveyance of sewage and waste water.
Drain-pipes—Cylindrical tubes used to form a drain.

EXCAVATION—A trench, pit, or tunnel dug out below the level of the ground.
Excavator—Labourer who digs and removes earth, etc., to level sites or form trenches, pits, and tunnels.

FENDER—Balk of timber placed outside a gantry to keep carts from damaging the uprights.
Flat centring—Temporary frame of wood on which a flat concrete floor is formed.
Flushing tank—Chamber filled with water and discharged at intervals to cleanse drains.
Flying shore—One placed horizontally across an open space between two buildings.
Fresh air inlet (abbreviation F.A.I.)—Inlet into disconnecting chamber of a drain to admit ventilation.

GANTRY—Temporary erection of squared timbers for dealing with heavy loads.
Granolithic—Species of fine concrete formed with granite chips used for paving and steps.
Gravel—Natural soil composed of small stones and sand.
Grease-trap—Form of trap to receive the discharge from a scullery sink.
Grub up—To break up and clear old foundations, drains, roots, &c., from a site.
Gully—Form of trap to receive waste water from ground surfaces or pipes.

HARD CORE—Hard dry broken rubbish.
Head—In gantries the beam carried by the uprights.
Hoggin—Screenings from pit gravel used for covering paths.
Holdfast—Iron spike with flat head for driving into brickwork.
Hoop-iron—Long flat strips of iron of various widths and gauges.
Horsing—Term used for strutting up centring from a solid base.
Hydraulicity—Capacity of cements and some limes to set without exposure to the air when mixed into a paste with water.

INSPECTION EYE—Opening in a drain or pipe by which it may be examined.
Invert—Lower part of a drain-pipe or sewer.

JUNCTION—Drain-pipe with side inlet for another pipe.
Junction block—Block built into sewer with inlet for drain-pipe.

LAGGINGS—Strips of wood nailed to centres to carry wide arches and vaults.
Lamp hole—Aperture for lowering a light into a drain.
Ledger—In scaffolding the horizontal timber carrying putlogs.
Lime—Material produced by calcining limestones.
Limekiln—Structures in which lime is calcined.
Loam—Soil in which clay prevails.

MADE GROUND—Ground which has been filled in, not virgin soil.
Main drain—Principal drain with which branch drains are connected.
Manhole—Chamber formed in the length of a drain for cleansing and to receive branch drains.
Metalling—Hard material forming the wearing surface of a road.
Monkey—Moving weight used in a pile engine for driving piles.

NEAT CEMENT—Cement used without sand.
Needle—In shoring a timber passed through a wall the ends of which are supported. Also the small timber inserted through wall-piece to receive head of raking shore.

PILES—Long timbers driven into loose ground to support superstructure.
Pile engine—Apparatus for driving in piles.
Plaster of Paris—Material produced by calcining gypsum (*selenite*).
Poling boards—Short boards used in timbering foundations.
Portland cement—Artificial cement of great strength and eminently hydraulic.
Pumice—A light volcanic stone.
Putlogs—Short square timbers used in scaffolding to carry scaffold boards.
Putlog holes—Holes left in brick walls to receive the inner end of putlogs.

QUICKLIME—Material produced by calcining pure limestone.

RAKING SHORE—One making an inclination with the horizon.
Retaining wall—One built to uphold a bank of earth.
Riding shore—One not carried down to the ground, but rising from the back of a raking shore.

SAND—Fine very hard material procured from pits, river beds, and the seashore, may also be crushed from sandstone.
Scaffold—Temporary erection from which permanent walls are constructed.
Scaffold boards—Stout boards with ends bound with hoop-iron, used to form platforms on a scaffold.
Scaffolder—Superior labourer specially engaged in erecting and altering scaffolds.
Scaffold height—Distance between successive ledgers in a scaffold, usually five feet.
Screw pile—Hollow cylindrical iron pile with large projecting screw at its base.
Selenitic lime or cement—One containing a small proportion of sulphate of lime, as plaster of Paris.
Setting—Hardening of a lime or cement mixed into a paste with water.
Sewer—Drain usually under public road to receive drainage of several buildings.
Shoring—The system of propping or strutting a building temporarily with timbers.
Silt—Muddy deposit from rivers.
Slaking—Chemical combination of quicklime with water.
Sleeper—In a gantry the horizontal beam on which the uprights stand.
Socket-pipe—One having socket formed at one end to receive end of next pipe.
Solepiece—Timber on which a system of shores rests.
Spigot end—End of a pipe that fits into socket.
Spoil—Material that has been excavated.
Standards—Vertical posts of a scaffold.
Steening—Brick lining without mortar in a cylindrical well or cesspool.

TAPER PIPE—One of which the diameter is regularly reduced from end to end.
Tar paving—Mixture of tar and shingle used to pave footpaths and areas.
Three-quarter pipe—Pipe of which three quarters of the circumference is formed.
Trap—In drainage a device to prevent the admission of sewer gas into a building while allowing sewage to pass through it.
Traveller—Small crane mounted on rails and able to move to and fro.
Trench—Excavation with parallel sides for the base of a wall or for a drain.
Turning piece—A small centre cut from a thick board on which arches with narrow soffits are constructed.

UPRIGHT—Vertical timbers of a gantry.

WALINGS—Horizontal timbers used in connection with piling and in timbering excavations.
Wall piece—In shoring, a wood plate placed vertically against the wall.
Water seal—Depth to which the upper part of a trap extends below the water standing in it.

BRICKLAYING AND PAVING

AIR BRICK—A brick perforated to admit air into a building.
Air Flue—A conduit for the conveyance of air.
Annular Vault—A vault springing from two circular concentric walls.
Arch—An arrangement of blocks of material in the line of some curve supporting one another by mutual pressure, the outermost blocks resting on or against an abutment.
Architrave—The ornamental band of mouldings run round a door or window opening.
Archivolt—The ornamental band of mouldings worked on the voussoirs of an arch.
Arch Stone—See *voussoir*.
Archway—An arched opening in a building.
Axed Arch—A brick arch of which the bricks are roughly cut into the form of voussoirs.

BACK HEARTH—That part of a hearth within the recess for a fireplace.
Backing—The inner portion of a wall behind the facings.
Backs—Large shallow tanks into which malm earth is run to consolidate.
Bat—Either portion of a brick formed by dividing it across its length.
Batter—A term signifying that the face of a wall is not vertical, but is inclined backwards from its base.
Beam Filling—The filling in of walling between joists or rafters.
Bed—The upper and lower surfaces of a brick or similar block of material.
Bed Timber—The laying of timber plates on a mortar bed.
Bevel—The surface formed by cutting off an arris by a plane; *or*, a tool for setting out surfaces at various angles.
Bird's Mouth—A notch cut in the end of a brick used in bonding obtuse entering angles.
Blades—Loosely built walls of unburnt bricks formed in a kiln for burning.
Blue Brick—A strong, dense brick, dark blue in colour, largely made from Staffordshire clays.
Bolster—A tool used in cutting bricks.
Bond—The arrangement of bricks or stones throughout a wall so that successive courses interlock.
Bonding Iron—A small iron tie used to bind the two parts of a hollow wall.
Breaking Joint—The arrangement of materials so that cross joints in adjacent courses do not coincide.
Breeze—Fine ashes used in burning bricks.
Breeze Bricks—Blocks of breeze concrete the size of an ordinary brick.
Brick—A material produced by burning special forms of clay.
Brick nogging—Brickwork filled in between the timbers of a wood partition.
Brick on Edge—Bricks laid not flat but on edge.
Build-in—Fixing work into a wall as it proceeds.
Bullnose Brick—One having a quadrant curve at one corner.
Bull's Eye—A circular window or opening.
Burrs—Lumps of brick vitrified and run together in burning.

CASING—The covering of the outer face of a wall with another thin substance.
Cement Fillet—A band of cement, the upper surface sloped or weathered.
Chamfer—The surface formed by the cutting of an arris diagonally by a plane.
Chase—A shallow channel cut or formed on a wall face.
Chimney—A conduit for smoke or fumes.
Chimney Bar—An iron bar supporting the arch over a fireplace.
Chimney Bond—A special form of bonding used in chimneys.
Chimney Breast—The side of a chimney or group of chimneys next a room.
Chimney Piece—The fitting, usually ornamental, fixed in front of a fireplace.
Chimney Pot—A tube of terra-cotta or earthenware forming the finish to the top of a chimney.
Chimney Shaft—A large single chimney connected with a furnace or boiler.
Chimney Stack—A structure in which several chimneys are contained.
Chuffs—Bricks on which rain has fallen while burning—soft and useless.
Circular Work—A term applied to any work having a cylindrical face.
Clamp—A carefully-built stack of dried raw bricks for burning.
Closer—A brick cut in half lengthwise.
Coping—The course covering the top of a wall.
Copper—A receptacle for heating water by means of a furnace.
Corbel—A projection from the face of a wall to carry some superstructure.
Corbel Table—A continuous projection carried on corbels or projecting arches.
Core—The heart or centre of a wall; applied also to other objects.
Core and Parge—The operation of finishing the interior surface of a chimney flue.
Cornice—An ornamental course projecting from the face of a wall at or near the top.
Course—A layer of materials contained between two horizontal joints.
Creasing—Courses of tiles set in cement projecting beyond each face of a wall below a brick-on-edge coping.
Crown—The top of an arch or vault.
Cut and Pin-in—Cutting out a part of a wall to receive a step or other object and fixing same in securely.
Cutters—The best malm bricks used for gauged work.
Cylindrical Vault—One in the form of a segment of a cylinder.

DAMP COURSE—A layer of material impervious to moisture introduced into a wall.
Damper—A sliding diaphragm introduced into a flue to regulate the draught.
Dinas Firebrick—The most refractory firebrick made from Glamorganshire fireclay.
Discharging Arch—An arch built over a lintel to relieve it of the weight of the superstructure.
Dry Area—A space constructed outside a wall below the ground level to keep it dry.
Dwarf Wall—One that only rises a short distance from the ground.

EFFLORESCENCE—A floury substance, often occurring on new walls, due to crystallisation of salts in the materials used.
Elliptical Arch—One taking the form of an ellipse.
English Bond—The form in which headers and stretchers appear in alternate courses on the face.
Equilateral Arch—A pointed arch in which the chord subtending each curve equals the width at the springing.
Extrados—The upper surface of any arch.

FACINGS—Material of a selected quality for the face of a wall.
Faircutting—The careful preparation of bricks for special positions.
Fair Face—The face of a brick wall in which both headers and stretchers lie in a true plane.
Feeding Holes—Openings in a kiln to admit fuel.
Fender Wall—One built to carry the hearth of a fireplace.
Fillet—See *cement fillet*.
Firebrick—Bricks formed from refractory clays capable of withstanding high temperatures.
Fireclay—A refractory clay used in setting firebricks.
Fireplace—The place in a room provided for the fire.
Flat Arch—An arch formed with voussoir-shaped bricks, but having a flat soffit.
Flaunching—A weathered surface formed in mortar around a chimney pot.
Flemish Bond—The form in which headers and stretchers appear in the face alternately in every course.
Flue—A conduit for conveying air or smoke.
Flush—One surface is flush with another when they are in the same plane.
Flush-up—A term applied to filling up vertical joints with mortar.
Footings—Courses projecting on either side of the base of a wall to increase its bearing area and stability.
Frenchman—A tool used by a bricklayer in pointing.
Frog—A hollow formed in the face of some bricks.

GANISTER—An extremely refractory sandstone used in a powdered state for lining steel converters.
Gathering-over is causing successive courses of brickwork to overhang those below.
Gauged Brickwork—Work in which large bricks are rubbed down to exact dimensions.
Gault Bricks—Those manufactured from gault clay, usually hard and white.
Glazed Brick—One the face of which is covered with a transparent or opaque glaze.
Grizzles—Inferior soft bricks to which air has had access during burning.
Grout—Mortar or cement made liquid with water and poured into brick walls at intervals to fill up interstices.

HACKS—Long, low banks on which bricks are stacked to dry.
Haunch—The curved sides of an arch between the springing and crown.
Head—The horizontal member forming the top of an opening.
Header—A brick laid in a wall with its length perpendicular to the face.
Header Bond—A bond formed entirely of headers.
Hearth—A slab of incombustible material laid under and in front of a fireplace.
Hod—The receptacle in which a bricklayer's labourer carries mortar or bricks on his shoulder.

Hollow Wall — One in which a continuous cavity is provided between the inner and outer faces.
Honeycomb Wall — One built with intervals between the ends of the bricks.
Hood Mould — A moulding projecting beyond the wall above an opening.
Hoop-iron Bond—Strips of thin iron built into walls longitudinally.
Horseshoe Arch—One consisting of a part of a circle greater than a semicircle.

IMPOST — The top of a pier from which an arch springs.
Intrados—The under surface of any arch.
Inverted Arch—One of which the arch is formed below the level from which it springs.

JAMBS—The vertical sides of a door or window opening.
Jump—An abrupt change in the level of a horizontal course.

KERFS—Heaps of brick earth, dug and covered with fine ashes.
Kiln — A brick structure in which bricks are burnt.
King Closer—A brick cut to a bevel to show a face 2¼ in. wide.

LABOURS—A general term denoting work incidentally necessary, but not specifically described.
Lap — In brickwork, the horizontal distance between vertical joints in successive courses.
Larry — An instrument for mixing mortar.
Limewhite—A mixture of quicklime and water used as a wash.

MALM—A brick earth made in imitation of natural marl.
Marl—A brick earth containing much carbonate of lime.
Mat Sinking—A sunk space formed in the paving inside a door for a mat.
Mortar—The adhesive material formed of lime or cement and sand placed between adjacent bricks.
Mortar Board—A square board on which mortar is deposited on the scaffold.
Mortar Mill—A machine in which mortar is mixed.
Moulded Bricks—Those which have some special moulding on them.
Moulding—The process of forming clay into the form of a brick; also an ornamental contour applied to a surface to enrich it.
Mullion—A vertical pier sub-dividing an opening.
Mural—Appertaining to a wall.

NICHE—A recess formed in the thickness of a wall.
Nogging—See *brick-nogging*.

OBLIQUE ARCH—One in which the face is not perpendicular to the axis.
Offset — A ledge formed in a wall by reducing its thickness.
Oversailing Course—A course which overhangs the course below.

PANEL—A surface enclosed by moulding or other surfaces in different planes.
Parapet—A wall carried up above the level of the adjoining roof.
Parge—The process of rendering the inside of a flue.
Paviors—A hard quality of bricks used for paving.
Perpends—The perpendicular alignment of vertical joints.
Pier—A detached or projecting portion of brickwork or masonry carrying a concentrated load.
Pin-in—Fixing any work into a cavity prepared for it in a wall.
Pin-up—Finishing a new piece of wall tight up against superincumbent work.
Place Bricks — Soft under-burnt bricks, suited only for internal walls.
Plinth—A slight external projection at the base of a structure.
Plumb Rule—The tool with which a bricklayer ensures that walls are built truly vertical.
Pointing—The filling-in with mortar of joints in walling which have been previously raked out.
Pressed Brick—Bricks moulded by dry-clay machinery.
Pugging—A layer of material used to deaden sound.
Pug Mill—The receptacle in which brick earth is worked up before moulding.
Purpose-made Bricks—Those specially formed or moulded for a particular piece of work.

QUEEN CLOSER—A brick of the ordinary length and thickness, but only half the usual width.
Quoin — The external angles of a structure.

RACKING BACK—The end of a wall temporarily formed so that each course is set back by the extent of the lap.
Rake Out—The clearing out of mortar joints previous to pointing or rendering.
Ramp — A curved form connecting a higher and lower part of a wall.
Relieving Arch — See *discharging arch*.
Reveal — The vertical return on the outside of a door or window opening.
Rib — A projecting band, usually moulded, separating adjoining surfaces.
Rod—A standard measure of brickwork equivalent to 272¼ superficial feet of wall one and a half bricks thick.
Rough Arch—One formed with parallel sided bricks and irregular joints.
Rough Cutting—The cutting that may be done to brickwork on the scaffold or in position.
Rubbers—A special class of brick used for rubbed and gauged work.
Rubbing Stone—A gritty stone on which bricks are rubbed.

SAND MOULDING—Sprinkling the mould in brickmaking with sand, to prevent the clay adhering to it.
Scintling—Placing half-dried bricks diagonally at short spaces apart.
Scutch—A tool used for brick cutting.
Segmental Arch—An arch, the intrados of which forms less than a semicircle.
Set-off — A small ledge formed by reducing the thickness of a wall.
Shippers—Sound, hard bricks, not perfect in form, largely exported.
Sill—The horizontal member forming the bottom of an opening.
Skewback — The sloping abutment from which an arch springs.
Sleeper-wall — A low wall carrying the plate or sleeper for a floor.
Slop-moulding—When the mould in brickmaking is dipped in water to prevent the clay adhering to it.
Soil—Very fine ashes that are mixed with brick earth.
Splay Bricks—Those having one angle bevelled.
Splits — Bricks of usual length and breadth, but 1 in., 1½ in., or 2 in. thick.
Springer—The block of material from which an arch rises.
Springing—The horizontal line from which an arch rises.
Square—A tool used for setting out surfaces at right angles.
Squint — A brick used in bonding external obtuse angles.
Stilted Arch—One of which the springing is above the level of the impost.
Stock Board—The loose bottom of a brick mould.
Stocks—Hard, well-burnt bricks not perfect in form.
Stop—The term for the finish of a chamfer or moulding not run out.
Straight Arch—A gauged arch having a horizontal intrados.
Straight Joint—A vertical joint that extends through more than one course.
Stretcher—A brick laid in a wall, its length being parallel to the face of such wall.
Strike—A straight-edge used for removing surplus clay from a brick mould.
String Course—A small continuous horizontal projecting band or moulding.
Struck Joint—A joint with a weathered face, formed as the wall is built.
Surfacing Table—A table on which gauged work is set out.

TEMPERING—A process in preparing clay for brick-making.
Terra-cotta—A hard durable material composed of special clays and burnt in a kiln.
Tessellated Pavement — One composed of small cubes of suitable material.
Tessera—Small cubes of material used in forming mosaic work and tessellated pavements.
Tile Creasing—See *creasing*.
Tin Saw—A saw used for cutting lines into a brick.
Toothing—The end of a wall left with alternate courses projecting one quarter brick, with a view to continuous bonding when extended.
Trowel—The tool used for cutting and laying bricks.
Tuck Pointing—A narrow line of white lime putty worked on the face of ordinary pointing to imitate gauged work.
Tumbling—A method of finishing a sharply-inclined brick surface.

VERTICAL DAMP COURSE—One used in a vertical position in walls, the outer face of which is in contact with the soil.
Voussoir—Each of the wedge-shaped blocks of material of which an arch is formed.

WALL—A structure formed of small component substances used to separate adjoining areas or to enclose spaces.
Wall Tie—The ties of brick, terra-cotta, or metal used to construct the two parts of a hollow wall.
Washing—The process of mixing brick earth with mortar.
Weather Fillet—See *cement fillet*.
Weather Moulding—A moulding having its upper surface formed to throw off water.
White Bricks—Bricks of a whitish colour, largely made in Suffolk.
White Glazed Bricks—A brick with a fine white glazed surface.
Whitewash—A material made from whiting, often applied to brick interiors.
Whiting — A pure chalk ground in water and run through a fine sieve.
Wire-cut—A brick formed in a plastic clay machine.
With or Wythe—The partition separating the flues in a chimney stack.
Wood Brick—A block of wood the size of a brick built into a wall for fixing joinery.

MASONRY AND SLATING

ALABASTER—A very fine grained form of gypsum.
Apex Stone—The stone forming the top of a gable.
Architrave—In columnar architecture, the stone resting directly on the columns.
Architrave Moulding—A group of mouldings running round an opening.
Artificial Stone—A material manufactured in imitation of stone.
Ashlar—Masonry formed with carefully squared stones in regular courses.
Axe—A heavy tool with a chisel edge used in dressing granites.

BACK—Of a slate, the upper surface when laid.
Back-jointed—A rebate formed on the edge of one stone to receive the angle of another stone.
Baluster—A short stone shaft turned and moulded.
Balustrade—A row of balusters with continuous base and capping.
Banker—The bench on which a mason prepares his work.
Barrel Vault—A continuous vault, semicircular in section.
Base Bed—The lowest course of building stone in a Portland quarry.
Bath Stone—An oolitic limestone largely quarried near Bath.
Battlements—An indented parapet, finishing a wall.
Bed of a Slate—The under-surface as laid.
Bevel—A tool of brass or iron for marking irregular angles.
Block—A piece of unwrought stone as quarried.
Block-in-course—A class of masonry built with squared stones.
Blocking Course—A course of squared stones above a cornice.
Boaster—A chisel whose edge is from 1½ to 3 in. broad.
Boasting—Working a masonry surface with a boaster; in carving, cutting the stone roughly to the intended form.
Bond Stones—Stones which penetrate into the backing of a wall to assist bonding.
Boss—A projecting mass of stone at the intersection of moulded ribs, usually carved.
Broached Face—One worked with diagonal furrows produced with a point.
Broad Tool—A chisel about 4 in. wide, used for tooling.

CÆN STONE—A soft, white limestone imported from Normandy.
Cantilever—A shaped bracket of stone or slate, of which one end is pinned into a wall.
Carrara—A white Italian marble, used largely for chimney-pieces.
Centre Nailed—In slating, fixing slates near their centre.
Chalk—A calcareous earth sometimes hard enough for building.
Chilmark—An oolitic limestone found near Tisbury.
Chisel—A tool with a cutting edge from ¼ to 1½ in. broad.
Chiselled Work—A wrought surface left from the chisel.
Claw Tool—One like a broad chisel with teeth on the edge.
Cleavage Plane—The plane in which some rocks readily split.
Countess Slates—Those which measure 20 by 10 in.
Coursed—Built in regular horizontal courses.
Cover Tile—A rounded tile covering the joint of two adjacent tiles in some forms of tiling.
Crab—A form of crane used to lift large stones.
Cramp—A metal bar let into two adjacent stones as a tie.
Crenelations—The openings in an embattled parapet.
Cross-cut Saw—A two-handled, toothed steel saw for cutting soft stones.
Cross Vault—One produced by the intersection of two barrel vaults.
Curb Stones—Those forming a continuous edge, as in a path.
Curtail Step—The lowest step in a flight, with the outer end formed as a scroll.

DIAGONAL RIB—One running between the opposite angles of a rectangular vault.
Diaper-work—The enrichment of a stone surface with small geometrical designs.
Dolomite—A magnesian limestone in which carbonate of magnesia and carbonate of lime occur in equal proportions.
Dovetail Cramps—Slate cramps cut to form a double dovetail.
Dowel—A pin of slate or metal to secure one stone or piece of timber to the stone below it.
Draft—A strip or margin on either side of an arris wrought with a chisel.
Drafted Margin—A draft running round all edges of a stone.
Drag—A broad steel plate with a serrated edge for dressing soft stones.
Dragged Face—A stone face finished with a drag.
Dressed—A term denoting that a stone has been fashioned for its place before fixing.
Drip Stone—A projecting moulding above an opening to throw off water.
Droved Ashlar—A Scotch term for chiselled or random-tooled ashlar.
Duchess Slates—Those measuring 24 by 12 in.

EAVES COURSE—The lowest course of slates or tiles in a roof with eaves.
Embattled—A wall finished at the top with embrasures.
Embrasure—A notch or sinking in the upper edge of a parapet.

FACE—Of a stone, the side exposed when built into a wall.
Face Mould—A pattern giving the form to which a stone face is to be worked.
Feathers—Thin concave pieces of iron used in splitting granite.
Flags—Thin stones used for paving, often laminated.
Flint—Stones formed of nearly pure silica found with chalk.
Flyers—Steps in a flight, the fronts of which are parallel.
Formeret—The vaulting rib that forms the junction between a vault and the arcade wall.
Frame-saw—A large, toothless saw for cutting harder freestones.
Freestone—Any stone capable of being readily tooled.

GALLETING—Inserting small stone chips in broad mortar joints.
Gargoyle—A stone water-shoot, often grotesquely carved.
Gauge—In slated and tiled roofs, the distance from the tail of one slate or tile to the tail of the next.
Geometrical Stair—One formed with radiating steps round an open well-hole.
Glass Tiles—Pieces of glass cut to the form of tiles and laid in a tiled roof to give light.
Granite—An igneous rock composed of quartz mica and felspar.
Grit Stone—A hard sandstone.
Groin—The line formed by the intersection of two vaults at an angle.
Groining Rib—A rib built to support the groin of a vault.
Gypsum—A soft stone formed of hydrated sulphate of lime.

HAMMER DRESSED—Stone that has been dressed with a hammer only.
Heading—The vertical sides of a stone at right angles to the face.
Heading Joint—The joint between the headings of adjacent stones.
Head Nailing—Fixing a slate with nails close to the head.
Head of a Slate—The upper end as laid.
Hearting—The centre part of a wall between the facings.
Hewn Stone—Stone brought to a required form with hammer and chisel.
Hip-tile—A tile of special form used in tiled roofs to form hips.
Hood Moulding—Another term for a dripstone.
Hookstone—A stone which receives the hook or pin of a strap hinge, and is built into a wall or pier.

INTERMEDIATE RIB—One occurring between a diagonal rib and the transverse or wall rib, and springing from the shaft.
Irregular Coursed Rubble—Rubble in which the horizontal beds are not continuous.

JAMBSTONES—Stones used in building the sides of an opening.
Joggle—A joint formed with an indentation in the surface of one stone to receive a projection on the adjoining stone.
Jumper—A long iron chisel used for drilling holes.

KENTISH RAG—A form of compact limestone suitable for rubble work.
Kerb—See *curb*.
Key Course—The course of stones forming the crown of a barrel vault.
Key Stone—The stone forming the crown of an arch.
Knapping—The process of splitting flints for walling.
Kneeler—A square seating worked in certain coping-stones in a raking parapet.

LABEL OR LABEL MOULDING—See *dripstone*.
Lacing Courses—Bonding courses of ashlar or brick used in flint walls.
Ladies—Slates measuring 16 by 8 in.
Laminated—Stones which readily split into thin layers.
Lap—The extent to which the head of one slate or tile is covered by the tail of the next course but one above it.
Lewis—A form of iron wedge used for lifting heavy stones.
Lierne Rib—A short cross-rib in a vault that does not spring from a shaft.
Limestone—A general term for all stones of which the principal ingredient is carbonate of lime.
Lintol—A horizontal beam of stone or timber, spanning a door or window opening.

MALLET—A tool with circular head of hard wood for striking cutting tools.
Marble—Carbonate of lime in a crystalline or semi-crystalline form.
Margin—That part of the back of a tile that is exposed when laid.

Masonry—The art of forming and uniting stones to form walls and other structures.
Millstone Grit—A very hard, coarse-grained sandstone.
Monolith—A column or other object formed of a single stone.
Mortice—A sinking cut into a stone.

NATURAL BED—The bed on which a stone was originally deposited in formation.
Newel—A vertical column or pier placed at the angles of a flight of stairs or forming the centre of a spiral stair.
Nippers—A pair of iron claws used for lifting stones.
Nosing—The salient edge of a step, often moulded.

OBELISK—A lofty pillar, square on plan, and diminished towards the top.
Onyx—A term applied to an Oriental alabaster, and to certain marbles found in Algeria and Mexico.
Oolites—The class of limestone formed of minute egg-shaped grains.
Open Newel Stair—One in which the steps are built in at one end, and with no central newel.

PANTILE.—One that is not flat but undulating in form.
Parian—A white marble, from the Greek island of Paros.
Patent Axe—An axe formed of several strips of steel, each with a cutting edge.
Pentelic Marble—A white marble, from Mount Pentelicus in Greece.
Pick—A heavy hammer-shaped tool with sharp ends.
Pick-Faced—Work that has been dressed with a pick, or in freestones with a point.
Pillar—A disengaged stone column generally irregular in plan.
Pinnacle—A pointed termination at the top of a buttress or gable.
Pitching—The process of knocking off rough lumps from a block.
Pitchings—Cubes of granite used for paving.
Pitching Tool—Resembles a chisel, but has a bevelled not a cutting edge.
Plain Ashlar—Ashlar the surface of which has been rubbed.
Plugs—Circular conical pieces of iron used with *feathers* in splitting granite; also pieces of wood or lead let into stones for fixing joinery.
Point—A tool with a narrow chisel edge used with a mallet.
Polishing—A process by which a smooth, glossy surface is given to marbles and granites.
Polygonal Rubble—A carefully formed rubble wall without horizontal beds.
Porphyry—An igneous rock of a reddish colour found in Egypt; generally any rock containing embedded crystals distinct from the main mass.
Portland Stone—An oolitic limestone largely quarried in the island of Portland.
Princesses—Slates measuring 24 by 14 in.
Punch—A tool with a narrow chisel edge used with a hammer.
Punched Rock Face—A rough face formed with a punch.
Purbeck—A shelly marble found in Dorsetshire.

QUARRY—A place from which any stone or slate is obtained.
Quarry Sap—The moisture contained in all stones when quarried.
Quarry-worked—Stone that is dressed at the quarry before delivery.
Queens—Slates measuring 36 by 24 in.

RADIATING JOINTS—Those which radiate from a common centre.
Raglet—A groove cut in stonework to receive lead flashings.
Random Rubble—Rubble masonry in which all joints are irregular.
Random Tooled—Masonry in which the tool-marks are irregular in direction.
Rib—A narrow arch below the surface of a vault to support or enrich it.
Ridge-rib—A rib forming a division at the top of adjacent severeys.
Ridge-tile—A tile of special form for covering the ridge of a roof.
Ripper—A tool used for cutting old nails in repairing slate roofs.
Riser—The vertical front of a step.
Roach—The topmost bed of Portland stone available for building.
Roestone—An oolite, the grains of which are of large size.
Rouge Royal—A reddish veined marble, found in France and Belgium.
Rubbed Work—Plain work, the face rubbed down with freestone.
Rubble—Masonry built of rough stone not reduced to a uniform size or carefully wrought.
Rusticated Masonry — Masonry formed of large stones, the face left rough and with a drafted margin.
Rustic Quoin—Quoins the edges of which are bevelled so that the face stands in front of the wall face.

SADDLEBACK COPING—A coping, the top of which slopes in two directions.
Saddleback Joint—A joint used on weathered surfaces to prevent water from soaking in.
Sandstones—Those composed of grains of sand cemented together.
Sarking Felt—Felt used for lining roofs.
Scabbling—Consists in shaping blocks roughly by knocking off irregularities.
Scabbling Hammer—A very heavy hammer used in granite work.
Scribe—Incising the outline of a moulding with a sharp pointer.
Sedimentary Rock—Stone that has been deposited by the action of water.
Self-faced—A term applied to slate slabs when used just as split.
Serpentine—A soft, mottled, richly-coloured stone, used for decorative work.
Setting—The process of fixing dressed stones in their position.
Setts or Paving Setts—See *pitchings*.
Severey—A compartment of a vault between two main ribs.
Sicilian Marble—A whitish-veined marble, largely used for lavatory tops.
Sienna Marble—A rich clouded yellow marble found near Sienna, Italy.
Slate—A sedimentary rock that has been subjected to great pressure.
Slating Battens—Strips of deal sawn to sizes, to which slates are nailed.
Slurry—A mixture of stone dust and lime.
Snecks—Small squared stones used in rubble work to square up irregular courses.
Spalling Hammer—A hammer weighing about 12 lb., used for knocking off rough lumps.
Spalls—Rough pieces knocked off large blocks.
Spandril—A space triangular in form; the enclosing lines may be straight or curved.
Spire—The termination of a tower, circular or polygonal, the sides converging to an apex.
Splitters—Small chisels formed with a cup-shaped or hollow end.
Spurstone—A stone, usually of granite, used to protect the lower part of gateways.
Square—A right-angled tool made of iron plate.
Stairs—A series of stone blocks so disposed as to give access from one level to another.
Step—One of the blocks forming stairs.
Stone-cutting—The art of hewing or dressing stones to definite shapes.
Stone Tiles—Large slabs of laminated stones, used as a roofing material.
Stooling—The base to receive a jamb or mullion worked in the same block as the sill.
Straight-edge—A rule whose two edges are parallel.
Stratified—A stone that has been deposited in regular layers or strata.
Stroked Work—Finished like tooling, but tool-marks are formed diagonally.
Summerstone—The lowest stone at the side of a gable which includes the first portion of the coping.

TABLED JOINT—One in which part of the bed of one stone is let into the next course.
Tacks—Strips of metal used to support new slates in repairing a roof.
Tail—The lower end of a slate or tile.
Templet—A block of stone placed in a wall or pier to receive the end of a girder or beam. [*See also* page 311.]
Threshold—A block of stone forming a doorsill flush with the floor.
Throat—A hollow groove under a projecting sill or coping.
Through-stone—A bond stone passing through the whole thickness of a wall.
Tierceron—See *intermediate rib*.
Tilting Fillet—A strip of wood used to raise the bottom or one edge of slates or tiles.
Tisbury Stone—See *chilmark*.
Tooling—Finishing a stone surface so that regular tool-marks are displayed.
Torching—Pointing applied to the underside of slate or tile roofs.
Tracery—The disposition of bars in an arch or window so as to form geometrical designs.
Trammel—A rod, or arrangement of rods, for describing large curves.
Transverse Rib—The one in a vault that runs at right angles to its main axis.
Tread—The upper surface of a step.

UNCOURSED RUBBLE—See *random rubble*.

VALLEY TILE—A tile of special form used in tiled roofs to form valleys.
Venetian Tile—A tile with raised edges used with cover tiles.
Verde-Antique—A mottled green serpentine much used for paving.
Vermiculated Work—A form of rusticated work disposed in lines like the undulations of a worm.
Viscountess Slates—Those which measure 18 by 10 in.

WALL RIB—See *formeret*.
Water Table—A projection with a weathered surface, used in buttresses to throw off water.
Weather Tiling—Vertical tiling hung on walls to protect them.
Whitbed—The bed in a Portland stone quarry next below the roach.
Willesden Paper—A specially prepared rot-proof material used under slating.
Winder—A step in which the tread is wider at one end than the other.

YORK STONE—A hard, laminated sandstone, suited for steps, pavings, and templates, largely quarried in Yorkshire.

ZAX—The tool with which slates are trimmed.

CARPENTRY & CABINET WORK

ADZE—A long-handled tool of the axe type used in heavy carpentry for dressing large pieces of timber. It differs from an axe in several details, but the most noticeable is that the blade is at right angles instead of in line with the handle.

Angle Board—A board with V grooves in which to plane angles, fillets, round rods, etc.

Astragal — A semicircular moulding which projects. When flush with the surface it is a *bead*.

Auger—A long boring tool, usually fitted with a transverse handle like a large gimlet.

Auger Bit—A bit of the auger type used in a brace or machine.

Axe—Used for felling trees and chipping and splitting wood. When small and light it is called a *hatchet*.

BACK SAW—A saw stiffened by a metal back. Tenon and dovetail saws are examples.

Badger Plane—A large rebate plane.

Balk—A squared trunk or log.

Bar Clamp — A clamp the body of which is a bar on which the loose jaw slides.

Barefaced Tenon — A tenon shouldered only on one side and flush on the other.

Batten—A piece of wood screwed or nailed on a surface to give strength, usually to stiffen cross grain or hold boards together.

Baywood — An inferior species of mahogany.

Bead—A small rounded moulding with a quirk on one or both sides.

Bead Plane—A plane with its sole and cutting edge of a form for planing beads.

Beam—A long piece of timber of large section, generally used in a horizontal position for spanning, and supporting weights.

Beaumontague — A stopping composed chiefly of resin and beeswax used for filling holes and defects in cabinet work.

Bench — The table on which woodwork is done. It is provided with a vice and stop.

Bench Hook—A block of wood which fits against the edge of the bench, and is used as a stop for cross-cutting pieces of wood on the bench.

Bench Knife — An appliance sometimes used for holding wood while planing.

Bench Planes—The planes constantly used and kept on the bench. Generally understood to mean the jack, trying, and smoothing planes.

Bench Screw—The name sometimes applied to the vice used for gripping wood at the bench.

Bevel—An adjustable instrument used for testing angles. Angles themselves are also called *bevels* when they are not square.

Birdsmouth — An angle notched out of the end of a piece of timber to enable it to fit on to the angle of another piece.

Bit—Generally a boring tool for use in a brace, but the term includes all cutting tools not permanently attached to their handles.

Block Planes — Small metal planes, generally with the bevel of the cutting edge upwards and the iron lying at a low angle.

Bolection Moulding—Moulding which stands above a surface and fits over an edge.

Bolt—Bolts for wood generally have square nuts and rounded heads, and a square body extending an inch or so from the head to prevent the bolt from turning.

Bow Saw — Also called *frame saw*, or *turning saw*. A narrow saw fitted in a frame which keeps it from bending.

Box Tenon—A tenon sometimes used on the ends of corner posts to fit the mortises of two rails which meet there at right or other angles.

Brace—The appliance used for operating boring bits. Also the term used to signify a strut or bar of any kind for increasing the rigidity of a frame or other structure.

Brad—A variety of small nail, less frequently used than formerly.

Bradawl— The tool used for making very small holes in wood.

Breaking Joint—Arranging end grain joints in alternate positions, as in segmental work.

Bridle Joint — A form of joint in which the end of one member fits over a tongue cut in the body of the other.

Buckle — A saw blade out of truth through being in an unequal state of tension is said to be *buckled*.

Buhl Work — Inlaying with other materials than wood.

Bull-nose Plane—A small metal plane in which the portion of the sole in front of the iron is connected with the body of the plane by being arched over the mouth, and the shavings have to escape at either side.

Butt Hinges — The common type of hinge with square edges intended for sinking into the surface of the wood.

Butt Joint—A joint in which the two connected parts merely abut against each other.

CALLIPERS—An instrument with adjustable arms used chiefly for measuring diameters of circular work where a rule cannot be used.

Camber—The amount of arch given to a horizontal beam to counteract the effect of sagging.

Carcase—The main body of a structure without its minor fittings.

Caul—The piece of metal or wood used for maintaining even pressure on veneer until the glue has set.

Centering, or Centre—The temporary wood structure necessary for building brick, stone, or concrete arches on.

Centre-bit—A bit with a central point which projects into the wood and assists in starting and keeping the bit on the centre required.

Chalk Line—A reel of fine cord used for marking straight chalk lines on surfaces.

Chamfer—The bevelling off of square corners. The term is applied both to the operation of chamfering and to the angle or chamfer itself.

Chariot Plane—A small metal plane with wood wedge and deeper front than a block plane.

Chase Mortise—A mortise made long enough to permit the insertion of a member which cannot be put directly in from the front. The extra length is afterwards filled up.

Check—Another name for a rebate or shoulder.

Chisel—A long, narrow, flat cutting tool sharpened at its end.

Chuck—A lathe accessory for securing work to the mandrel.

Circular Saw—A machine saw in the form of a circular plate.

Clamp, or Cramp—An appliance for holding parts together by pressure. Also the act of clamping.

Cleading—Timbering of a shaft, mine, or cylinder.

Cleat—A wood clamp which, in addition to squeezing together, keeps a surface from warping. The term is also often used in the same sense as batten, but generally means a solid attachment to which some other part can be connected.

Clinch, or Clench—The bending over of the protruding point of a nail.

Coach Screw—A large screw for wood provided with a square head on which a spanner is used.

Cofferdam—A watertight enclosure of piles and boarding under water. It is a temporary construction to facilitate the laying of foundations and supports for bridges and piers.

Compasses — Instruments used for dividing and for describing circles and curves up to about 8 in. radius. They are of metal, and generally provided with a wing and pinching screw.

Compass Saw — A saw for cutting sweeps. It resembles a keyhole saw, except that it is larger, and has a handle of the tenon saw type.

Cornice—The top horizontal moulding of any structure.

Countersink—To sink the head of a screw flush with or below the surface. Also the name of a bit for enlarging the hole for the purpose.

Cramp—See *clamp*.

Cross-cut Saw—A saw intended for cutting across grain. Unless otherwise specified, a large two-handled saw is meant.

Cup Chuck, or Bell Chuck—A lathe chuck bearing some resemblance to a cup or bell. Short lengths of wood are chucked by having an end driven tightly into it.

DEAL—The various kinds of pine are commonly called deal. Also, 3-in. boards 9 or 10 in. wide.

Dividers — Small compasses used either for dividing or for striking circles.

Dog—A staple used for temporarily holding pieces of wood together, generally while glue is setting.

Double Tenon—Two tenons running side by side in separate planes.

Dovetail—A form of interlocking joint often employed when ends of wood meet at right angles.

Dovetail Saw—A fine saw for cutting dovetails.

Dowels — Hardwood pins used in edge joints and for numerous other purposes.

Draw Bore Pin—A metal pin used for drawing mortise and tenon joints together.

Drawer Lock Chisel—A bent chisel for working in confined situations.

Draw Knife —A large knife with a handle at each end.

Dress—To plane the surface of a piece of wood true is to dress it.

Dry Rot—A disease of timber generally brought about by want of ventilation and dampness.

ELEVATION—In a drawing, the front view of an object. If specified as side elevation, end elevation, or sectional elevation, the points of view vary accordingly, but they are always taken in a vertical plane with the object standing in its normal position.

End Grain—A face of a piece of wood which exposes the ends of the fibres.

Expansion Bit, or Extension Bit—A bit which can be adjusted to bore holes of different diameters.

FACE MARK—A mark put on one face of a piece of wood to indicate its intended position, or that it has been planed true.

Face Plate — The flat plate chuck of a lathe.
Fanlight — A sash over a door or window.
Fence—The guide used on saw tables, jointing, and other machines.
Fillet—Plain hollowed moulding occupying interior angles.
Fillister — A rebate plane provided with a guide.
Finish—The cleaning up, smoothing, varnishing, and polishing operations that follow the actual construction of anything.
Firmer Gouges and Chisels—Are those used for ordinary work. In stoutness they come midway between paring and mortise tools.
Fished Joint—A butt joint held together by fish-plates.
Float—A file with extremely coarse teeth cut on one face.
Flush—Contiguous surfaces that are level with each other or on the same plane.
Flutes—A number of hollow fillets side by side, generally round a column.
Fork Centre—The pronged chuck of a lathe.
Fox Wedging — A stub mortise and tenon joint in which wedges are inserted in the act of driving in.
French Polish—Shellac varnish applied with a rubber.
Fret Saw — An extremely narrow saw with fine teeth used for sawing ornamental designs in thin wood.

GAUGE—Used for marking lines on a surface parallel with one of the edges.
Getting Out—To get out wood is to saw out and prepare ready for putting together the pieces required for a job.
Gimlet — A small boring tool with screw point and a transverse handle.
Glasspaper—Paper coated with powdered glass or flint. Also called *Sandpaper*.
Glue—An animal substance used to cement pieces of wood together.
Glue Pot—The receptacle in which glue is melted for use. It consists of an inner pot for the glue and an outer one for water.
Gouge—A gouge differs from a chisel in being curved in cross section instead of flat.
Grain—The fibres of wood are collectively called the *grain*, and the direction in which they run is called the *direction of the grain*.
Grindstone—A revolving stone for removing material from cutting tools preparatory to sharpening them on a stone of finer grain.
Gullet — In large circular and some other saws there is some amount of space between the bases of the teeth, and this is known as the *gullet*.

HALF LAP JOINT—Also *halved* joint, or *lap* joint. A lap joint in which half the thickness of each piece is cut away so that the combined thickness at the joint is no more than that of each single piece.
Half Rip Saw—A saw used for ripping, but which has smaller teeth than a regular rip saw.
Hand Saw—A saw intended primarily for cross-cutting, but used for general purposes. It has smaller teeth than saws for ripping.
Hand Screw—A wooden clamp consisting of two jaws operated by two long screws with handles at their ends.
Hardwood—The wood obtained from the broad-leaved varieties of trees.
Hatchet—See *axe*.
Haunched Tenon—A tenon reduced in width either for a portion or the whole of its length. Employed when there is an objection to cutting a full-width mortise.
Heading Joint—A butt joint between two lengths of timber whose ends meet on a joist.
Headstock — The part of a lathe carrying the mandrel which imparts rotary movement to the work.
Herringbone Strutting—The short crossed stays between floor joists.
Hinge — The means of attachment which permits doors and box covers to swing or fold.
Holdfast — An appliance used for holding work down on the bench.
Holding Up—Being large enough to finish to required dimensions.
Hollow Plane—A plane with rounded sole for planing hollows.
Hone — Also *oilstone*. A stone used for sharpening cutting tools.
Housing—A structure which encloses something. A joint in which the end of one member is enclosed in the other without being reduced to a tenon.

INLAY — Ornamental designs of a material let into the surface of another material.
Iron—The cutter of a plane or of any tool or machine in which it is detachable.

JACK PLANE—The plane used for roughing down a surface approximately true.
Jointer — A small planing machine which cannot be set to plane to a thickness. Also a hand plane of greater length than the trying plane.
Joists—The timbers on which flooring boards are laid.

KERF—The cut or space a saw makes in passing through wood.
Key—A term with several applications, but its general meaning is a small piece of wood inserted in joints to hold them together or across grain to prevent curvature.
Keyhole Saw — Also *pad saw*. A small saw suitable for cutting keyholes or curves.
King Post—The main central post of a truss.
Knot—A hard spot of timber due to a change in the fibres caused by a branch of the tree springing from there.

LAGS—Strips used for building up cylindrical bodies and boarding over ribs of centring. Also called *lagging* or *staves*.
Lathe—The machine used for woodturning.
Ledged Door—A rough door formed of boards held together by battens or ledges.
Level — An appliance used for testing the horizontal accuracy of surfaces. Also called a *spirit level*.
Lintel — The beam which supports the brickwork or masonry over an opening in a wall.
Lock Corners—A term applied chiefly to the corners of boxes made by machinery. They differ from dovetails in being parallel.
Long Tooth Gauge—A gauge used for marking lines on surfaces at a different level to the edge which guides the stock.

MALLET — A large-headed wood hammer used chiefly for driving chisels and gouges.
Mansard Roof—A roof with two different slopes. Also called *curb roof*.
Marking Out—Drawing either on a board or on the material itself the size and shape of anything that is to be made. Also called *laying out* or *setting out*.
Matchboards—Boards with a groove in one edge and a tongue on the other, so that a number of them will fit edge to edge.
Mitre—An angle joint between two pieces meeting at right angles, as in picture-frames.
Mitre Clamp—A clamp for holding mitre joints together temporarily.
Mitre Dovetails—Secret dovetails cut in a mitre joint.
Mitre Shooting Board—A shooting board for planing mitres.
Mitre Block—A block with saw cut or grooves to guide the saw in cutting mitres.
Mitre Box—A box open at the top and ends and having saw cuts in the sides to guide the saw in cutting pieces laid in the box.
Mortise — The slot or recess which receives a tenon.
Mortise Chisel—A very stout form of chisel used for mortises.
Mortise Gauge—A gauge with two marking points adjustable in relation to each other.
Muntins—The vertical dividing bars in a window, door, or other frame.

NEEDLES—Supports for scaffolding inserted in walls.
Needle Points—A kind of needle without an eye used in cabinet work in place of fine nails.
Newels—The main posts which support the handrails of stairs.

OGEE —A moulding consisting of a concave and convex sweep dying into each other.
Oilstone—The stone used for sharpening tools. So called because it is used with oil on its surface.
Ovolo — A round moulding of about a quarter of a circle, but sometimes elliptic in form.

PAD SAW—A narrow saw held by pinching screws in a slotted handle long enough to enclose the saw when not in use. Also called *keyhole saw*.
Pair of Tenons—Tenons in line with each other. Not the same as double tenons.
Panel — A sheet of thin wood used for filling the open area in a frame.
Panel Gauge—A gauge long enough to include about 18 in. or 2 ft.
Panel Saw—A small type of hand saw used for light work on the bench.
Paring Tools—Long, thin gouges and chisels intended for paring without the use of a mallet.
Parquetry—Flooring made by laying hardwood blocks in various geometrical patterns.
Piles—Large wood posts driven into the ground.
Pincers—A gripping tool for withdrawing nails.
Pinned Joint—A joint in which pins or pegs are driven through to assist in holding the parts together.
Pitch — The inclination of a roof or stairway. It is known as *high* or *low* pitch according to the degree of slope. Also the height of an arch.
Plan — A view looking down on top of an object.
Plane—A cutter carried in some form of block which compels it to cut a thin uniform shaving.
Plane Iron—The cutter of a plane.
Pliers — Narrow-jawed pincers of various kinds employed for bending wire and for numerous other purposes.
Plough — A plane for cutting the grooves for panels and tongued joints.
Plumb—Being in line vertically.
Plumb Bob—A weighted string, sometimes in connection with a straightedge, used for testing the vertical accuracy of work. Also called a *plumb line*.
Poppet—The adjustable back centre of a lathe. Also called *tailstock*.
Punch — A steel pin used in driving nails below the surface.
Purlins—Members which unite the trusses of roofs in longitudinal directions.

QUARTERING—The bars or strips produced by ripping deals into four pieces.

Queen Post—Distinguished from king post chiefly by not being in the central position under a roof.

Quirk—The narrow groove or furrow at the side of a bead.

RAFTERS—The timbers to which the covering of a roof is attached.

Rail—A horizontal bar.

Raised Panel — A panel reduced in thickness at its edges.

Rasp—A species of coarse file used for wood.

Ratchet Brace — A brace with an arrangement which permits it to be worked in an arc of a circle and at the same time to turn the bit only in the forward direction.

Rebate—Or *rabbet*—A shallow channel or wide groove or recess planed in a surface.

Rebate Plane—A plane whose sole is no wider than the iron.

Rest—The arrangement on which the tool rests in a lathe.

Riffler—A small double-ended bent file or rasp.

Rip Saw—A saw with large teeth, intended for cutting in the direction of the grain.

Round Nose—A chisel used for scraping hollows in turned work in the lathe.

Round Plane—The reverse of a *hollow plane.*

Router — A small plane in which the iron may be set to cut to a certain depth below the sole. It is used for clearing out small recesses to a definite depth.

Rubber—The piece of cork or wood on which glasspaper is generally wrapped when in use.

SAG—The sinking of the middle part of a piece of timber which is supported at its ends.

Sandpaper—See *glasspaper.*

Sash—A frame in which panes of glass are fitted.

Sash Bars—The dividing bars which separate panes of glass in a sash.

Sash Door—A door with glass in its upper part.

Sash Plane — A plane to suit the mouldings of sash bars.

Saw Set—Any appliance used for setting or bending the teeth of saws sideways.

Saw Stool—A low heavy trestle used for resting planks on when sawing.

Scaffold—The temporary wood structure necessary in erecting buildings.

Scantling—A term used to signify the width of a piece of timber. It also means pieces of irregular width and thickness.

Scarf Joint — A lap joint used for joining two pieces of timber end to end to make one long piece.

Scotia — A concave moulding which increases in radius in its lower part. Also called *trochilus.*

Scraper—A small piece of sheet steel used for scraping the surfaces of hard wood smooth.

Screws—The threaded metal pins used for holding woodwork together. Also called *wood screws* or *screw nails.*

Screwdriver—A tool which fits the slots of screw heads, and is used for turning them. Also called a *turnscrew.*

Screwdriver Bit—A brace bit used for turning screws.

Scriber—A steel instrument for inscribing lines on wood. Also called *striking knife.*

Seasoned Timber — Timber from which the sap has been dried out.

Segments—Short sweeps used for building up circles or portions of circles.

Set — The set of a saw is the amount to which the teeth are alternately bent to opposite sides.

Set Square—A triangular square used for testing interior angles.

Shake—A longitudinal crack in timber.

Shank—The portion of a tool which connects with the handle, or fits the socket of a brace or machine.

Shell Bit—A bit used for screw holes. Its body is a channel of crescent-shaped section, and is sharpened at the end.

Shooting—Planing the edge of a piece of wood straight.

Shooting Board—A board for planing pieces of wood on.

Short Grain — When the distance across the grain is greater than the longitudinal dimension, the grain may be said to be *short.*

Shoulder—A step, or change of level in a surface, for another part to bear against.

Side Chisel—A chisel used at the lathe for parting, and numerous other purposes. Also called *side tool* or *turning chisel.*

Single Iron—A plane iron used without a back iron.

Skew—Anything set obliquely or at an angle to something else. In skew-mouthed planes, the cutting edge is out of square with the body of the plane.

Skew Nailed—Nails driven in at an angle at the feet of posts, and in similar circumstances. Also called *toe nailed* or *tusk nailed.*

Slip — A small piece of oilstone used in the hand.

Slip, or Slot Mortise—A mortise that is open at the end of the wood as well as going through from one face to the other.

Smoothing Plane—A short plane used for smoothing surfaces.

Socket Chisels and Gouges—Stout chisels and gouges formed into a socket at the shank end into which the wood handle is driven.

Sole, or Sole Piece—The piece of wood used as a base on which to rest the ends of posts or uprights.

Splice Joint—A *scarf joint.*

Spokeshave—A tool consisting of a knife set in a body or guide, provided with a handle at each end.

Sprigs—Small nails with very small heads.

Spring Dividers — Dividers which spring open as the wing nut is run back, and keep to the largest extension the position of the nut permits.

Staple — A piece of U-shaped iron, with pointed ends. A modified form for holding joints is called a *dog.*

Stile—The vertical side pieces of a door or other frame.

Stop — The block or catch near the front end of a bench against which the wood presses when being planed. Also the shoulder which stops a door or drawer.

Stop Chamfer — A chamfer which finishes short of the extreme point it could be carried to.

Stopping—Any plastic material used for filling small holes in order to make an unbroken surface.

Straightedge—A long piece of wood or other material with a perfectly straight edge, used for testing the accuracy of flat surfaces.

Strap — A bar of iron of rectangular section used for binding timbers together at their joints.

Strut—A stay, brace, bar, or support in compression in a diagonal position.

Stub Tenon—A short tenon which does not go through the part into which it fits.

Studs, or Studding — The vertical bars in lath and plaster partitions.

Stuff — A common shop term for timber.

Stump Tenon—A tenon made thick for a short distance from its root and thin the remainder of its length. The term is also used for *stub tenon.*

Sweep — The term is applicable to almost all curved portions of work, or pieces of wood, when the radius is not very small.

TANG—The pointed shank of a tool which is driven into the wood handle.

Templet, or Template — A pattern, generally in the form of a thin sheet of material, from which the shape of the actual work is marked or tested.

Tenon—The shouldered down end of a piece of wood which fits into the mortise or socket of another piece.

Thumb Plane—A very small plane of the smoothing plane type.

Toe Nailed—See *skew nailed.*

Tongue—A projecting ridge which fits into a groove in an adjoining piece.

Toothing Plane—A plane with a serrated iron, used in preparing surfaces for veneer.

Torus—A large bead with a fillet.

Trammels—An instrument for marking circles and curves of larger radius than ordinary compasses.

Trestles—Light supports consisting of four spreading legs and a narrow top, used for resting planks or work on.

Trimmer—A shearing machine for wood. Also a beam supporting the ends of joists.

Trochilus—See *scotia.*

True — Surfaces that are straight, level, or accurately formed to the shape required, or square, or concentric with each other, are said to be *true.* When not so, they are out of truth.

Truss—The stiffening of a horizontal beam by braces, which convert it into a rigid angular frame.

Trying Plane—A large plane which generally follows the jack plane for finishing and making surfaces true.

Try Square — An ordinary square, consisting of a stock and blade, used for testing the accuracy of work.

Turning Chisel—See *side chisel.*

Turnscrew—See *screwdriver.*

Tusk Nailed—See *skew nailed.*

Tusk Tenon—A tenon with a stump or tusk at the root.

Twist Bit—A bit with a spiral body.

UNDERCUT—A shoulder or similar part which overhangs, or has more cut away from its base than from its upper part.

VARNISH—A resin or gum dissolved in a suitable liquid.

Veneer—Very thin fancy wood glued on to the surface of an article constructed of cheaper wood.

Veneering Hammer — A hammer with a very wide edge, used squeegee fashion on veneer, instead of using cauls.

Vice, or Vise—An appliance attached to the bench and used for gripping.

WARPING—The twisting or springing of wood caused by unequal shrinkage. The term generally means an actual twist or wind, but sometimes is used when only curvature is meant.

Whet—To sharpen a tool on a hone.

Winding—The twist, or cast, or wind that sometimes develops in large pieces of wood.

Winding Strips—Parallel strips used for detecting the amount of twist in the surface of long pieces of wood.

Wing Compasses — Compasses with an arm and pinching screw for holding the legs at a fixed distance apart.

Wire Nails—Nails made with parallel bodies in great variety, and now the most commonly used kind of nail.

Wood Screw — The kind of screw commonly used for woodwork.

BUILDERS' FINISHING TERMS

AIR COCK—A tap to allow of the escape of air.
Anaglypta—A wall-covering modelled in relief.
Anchor Plate—A plate built into a wall to hold down some object.
Angus Smith's Solution—A preservative solution used for iron pipes.
Anti-syphon Pipe—An air pipe to counteract the tendency of traps to syphon out.
Apron—A strip of lead placed below a window, chimney, etc., and dressed on to the roof covering.
Arabesque Glass—A form of rolled glass with an ornamental pattern.
Axle Pulley—A pulley arranged in a vertical plate used in hanging sashes.
Automatic Flushing Cistern—A cistern arranged to discharge its contents as soon as it is filled.

BACK PUTTY—The putty placed between a pane of glass and the rebate of the sash.
Balance Weight—A weight used in sash frames to counterbalance the frame.
Barff's Process—A method of protecting iron by forming a coating of black oxide.
Bases—Those pigments which give opacity and body to paints.
Bastard Flatting—A flatting coat to which a little clarified oil or size has been added.
Bearing Plate—An iron plate used between a strap and a piece of timber.
Bell Board—A board on which a series of bells are attached.
Bib-cock—A form of cock which delivers water from the end of a pipe.
Blister—In painted work small parts of the paint that have become separated from the surface covered and raised.
Blown Joint—A soldered lead joint made with a blowpipe.
Bobbins—Boxwood balls used in bending lead pipes.
Bolt—A curved piece of wood used in bending lead pipes; a metal fastening for a door catching in a staple or thimble.
Boot Boiler—A form of boiler used at the back of a kitchen range.
Box Girder—A girder having two parallel webs.
Bracketing—Piece of wood to receive lathes for plaster cornices.
Brad—A small nail with a head on one side only.
Brazing—The joining two pieces of metal by means of brass solder.
Bringing Forward—Painting portions of work one or more extra coats before general painting.
British Plate—Plate glass cast and afterwards polished.
Brunswick Black—A material formed of asphaltum and turpentine and applied to iron.
Bulb Iron—Iron rolled with one flat and one cylindrical flange.
Bullet Latch—A latch formed with a spherical catch like a bullet.
Bullion—The centre of a sheet of crown glass.
Burlap—A woven material formed of jute.
Burning Off—Removing paint by applying heat to the surface.
Burning In—Melting solder to fit lead in a raglet.
Burnt Joint—A lead joint formed with lead in place of solder.
CABIN HOOK—A freely-moving hook attached to a staple or plate.
Calcothar—Red oxide of iron.
Cames—Strips of lead having an H section used in lead glazing.
Cantilever—A beam built into a wall and supported at one end only.
Casement Fastener—A metal fastener to secure a casement to the frame.
Cast Iron—Iron that has been melted and cast in a mould.
Cathedral Glass—Plain, tinted glass used in lead glazing.
Cat Ladder—Light iron ladders used for giving access to roofs.
Ceiling Block—A block of wood used for attaching a gas pendant to a ceiling.
Cesspool—A sunk outlet to a lead gutter.
Chimney Bar—A wrought-iron bar built in under the arch of a chimney opening.
Chequer Plate—An iron plate with a raised chequered surface.
Circulating Pipe—A pipe through which hot water from a boiler is circulated.
Cleaning Eye—An opening inserted in pipes and traps to facilitate cleaning.
Clearcolle—Thin liquid glue used on porous surfaces before whitewash.
Clips—Metal bands placed round a pipe to fix same to woodwork.
Clout Nails—Flat-headed nails.
Coach Screw—A long screw of uniform diameter and with a square head.
Coarse Stuff—A mixture of lime, sand and hair for first two coats in plastering.
Cobweb Grating—A form of grating used as outlet to lavatory basins.
Coburg Varnish—A pale oil varnish.
Cockle Furnace—A furnace of thick iron used for heating air.
Collar—A lead disc temporarily fixed round a pipe during wiping a joint to catch the superfluous solder.
Coil—A pipe bent to and fro to give a large heating surface at any desired point.
Compo—A general term given to cement used for coating brickwork.
Composition Nails—Nails made of various alloys to avoid corrosion.
Concrete Float—A thick, heavy float used in finishing concrete paving.
Copper Bit Joint—A soldered joint made with a copper bit.
Copper Nails—Nails made of copper, usually in the form of clout nails.
Core—A thick iron bar fitted under a handrail; the rough centre for a plaster moulding.
Cottar—Wedge-shaped keys.
Countersunk Joint—One finished with a splayed head flush with the plate.
Cover Flashing—A strip of lead fixed into a wall and covering the top of a flashing.
Creeping—The slow movement of lead downwards on a steep roof.
Cross-garnet Hinge—A hinge in the form of a ⊢.
Crown Glass—Glass blown in globular form and afterwards flattened.
Crystal Glass—A very pure white quality of sheet or plate glass.
Cup-and-ball Joint—A joint giving free rotary motion, used for chandeliers.
Cups—Small brass cones fitted into wood beads to receive the heads of screws.
Cutting Wheel—A circular knife used in trimming wallpapers.

DADO—A horizontal division at the base of a wall.
Darby—A two-handled plasterer's float.
Dead Lock—A lock having only one bolt operated by a key.
Dished—A slightly hollowed bottom formed in lead-lined sinks and cesspools.
Distemper—A material similar to whitewash, but mixed with colouring pigment.
Double-arm Pendant—A form of gas pendant having two arms.
Double Laths—Laths of extra thickness.
Double Size—Size of twice the usual strength.
Double-swing Bracket—A gas bracket having two arms, both with movable joints.
Dovetail Lathing—A sheet of metal bent into a series of dovetail grooves.
Draw-off—A tap by means of which water may be drawn from a pipe.
Drawn Pipes—Lead pipes produced by machinery without any joint.
Drip—An abrupt change in the level of a lead flat.
Drip Pipe—A pipe used in steam heating systems to get rid of condensation water.
Drop Handle—A handle which is hinged to lie close against a door when not in use.
Dryers—Substances added to paint to assist the absorption of oxygen.
D Trap—An old form of trap, shaped like a ⌂.
Dubbing Out—The process of forming a core for plaster mouldings.
Dummy—A tool used by the plumber in pipe bending.
EARS—Flat projections cast on iron rain-water pipes for fixing them.
Eaves Gutter—A gutter to take rain-water fixed at the eaves.
Economiser—A metal shield to close the opening between a grate and the hearth.
Elbow—A socket joining two pipes at right angles.
Embossed Glass—Glass that has been ornamented by chemical process.
Escutcheon—A small shield placed round a keyhole opening.
Espagnolette Bolt—A long double-action bolt used to secure French windows.
Eye—A metal ring into which a bolt may be fitted.
Eye-plate—A plate by which an eye may be attached to woodwork.
Expanded Metal—Metal sheets perforated and drawn out to form a kind of netting.
Expansion Joint—A form of joint allowing of movement due to expansion.
Expansion Pipe—A pipe in a hot-water system to carry off or contain excess of water due to expansion.
Expansion Tank—A tank in a hot-water system to hold excess of water due to expansion.

FALL-DOWN STOP—A form of gate stop that is lowered when not in use.
Feather-edge Rule—A rule one edge of which is splayed off to a thin edge.
Feed Cistern—A small cistern to keep a boiler supplied with water.
Fine Stuff—A mixture of lime putty with a little sand and hair.
Finger Plate—A plate fixed to either face of a door above or below a lock.
Finial—An ornamental termination to a gable or hip.
Fining Float—Small float for working plaster mitres, etc.
Fire-bar—The horizontal bars which carry the fire in a grate, boiler, etc.
Fish-plate—An iron plate used in forming a fished joint.
Flake White—A form of pure white lead made in England.
Flange—The tension and compression members in an iron girder.
Flanged Joint—A lead joint formed with a flange below it to support the pipe on a floor.
Flashed Glass—White glass with a film of coloured glass overlaid.
Flashing—A strip of lead used to make watertight the joint between a sloping roof and a vertical face.
Flatting—A coat of paint that is finished without gloss.
Flitch—An iron plate placed vertically in a flitched beam.
Float—A flat wooden instrument for working the final coat in plastering.
Floating Rule—A long rule used in forming screeds and floating surfaces between screeds.
Floor Spring—A spring for automatically closing a door, fixed in the floor.

Flow Pipe—That portionof a circulating pipe from the boiler to the highest level.
Flush Bolt—A bolt let into a door or window so that the face is flush with the wood.
Flush Handle—A handle sunk into a door so as to be flush with its face.
Flushing Tank—A tank the whole contents of which are discharged at one time.
Fluted Sheet—Sheet glass rolled with ribbed rollers, producing flutes.
Foil—Thin leaves of copper and other metals, applied like gold leaf.
French Nails—Long thin wire nails with flat heads.
French Polish—A mixture of shellac and spirits of wine for polishing hard woods.

GALVANISED IRON—Iron covered with a coating of zinc.
Gasket—Strands of rope or cord driven into the joints of pipes.
Gas Tar—See *coal tar*.
Gauge—A measure of thickness of wire and metal; to mix materials in exact proportion with water.
Gauge Board—A board on which plasterers' materials are mixed.
Gauged Stuff—Coarse or fine stuff with which plaster of Paris is mixed.
Gauge Hook—A tool used by plumbers for shaving lead surfaces.
Gauge Rule—a rule used for forming sunk or raised plaster surfaces.
Gauging Trowel—A trowel used for gauging plasterers' stuff.
Gelatine Mould—Moulds formed of gelatine for casting plaster enrichments.
Gib—A bearing iron used in connection with cottars.
Gilding—A process of applying gold leaf to surfaces.
Glaziers' Putty—A mixture of whiting and linseed oil.
Gold Size—A material applied to surfaces to be gilded.
Governor—An automatic control to regulate the pressure of gas in buildings.
Grainers' Comb—A metal comb used to produce graining.
Graining—Finishing a painted surface to match the grain of wood.
Ground Brush—The brush used by painters for large surfaces.
Ground Glass—Glass the surface of which is rendered obscure by grinding.
Gudgeon—The term applied to the eye of a hinge.
Gutter Pipe—The pipe through which the contents of a gutter are discharged.

HACKING OFF—The process of removing old plaster.
Hacking Out—The process of removing broken glass and old putty.
Hair—In plastering, the long hair from the backs of oxen.
Hand Float—Small floats, usually of pine, used in plastering.
Hangers—The struts employed in trussing a timber beam.
Hasp—A hinged, slotted plate passed over a staple and secured with a pin or padlock.
Hawk—A small board with a handle used for gauging and holding plasterers' stuff.
Heel—In pipe bending, the outer side of the curve.
Hit-and-miss Grating—One of which the openings can be closed by sliding a perforated plate.
H-Iron—Iron rolled so as to have an H section.
Holding-down Bolt—A bolt used to secure any object to an anchor plate.
Hopper Closet—A closet in the form of a funnel.
Hydrant—A stand pipe to which a hose may be attached.

INGRAIN PAPER—Papers coloured throughout in their manufacture.

JAPAN—Lead paint mixed with varnish dried at a high temperature.
Japanese Gold Size—A preparation of gum anime and linseed oil.
Jhilmil—A form of metal lathing.

KEEN'S CEMENT—A preparation of plaster of Paris treated with alum.
Keying—The scoring of the surface of plaster to secure adhesion for the next coat.
Kicking Plate—A metal plate fixed to the bottom rail of a door.
Killed Spirit—Spirits of salts in which zinc has been dissolved.
King Bolt—An iron bolt taking the place of a king post in a compound truss.
Knotting—The process of killing or covering knots in woodwork before painting.
Knuckle—The projecting portion of a hinge through which the pin passes.

LAC—A resinous substance obtained from the East Indies.
Lacquer—A varnish made with methylated spirit.
Lapped Joint—In lead work a joint in which one sheet is covered by the edge of the next.
Larry—A rake used for mixing hair with coarse stuff.
Latch—A fastening which may be opened with a handle instead of a key.
Lath and a Half—A term applied to extra stout laths.
Laths—Thin strips of wood used as a groundwork for plastering.
Lattice Girder—A girder of which the web is formed of iron lattice work.
Laying—Another term for rendering in plaster work.
Laying Trowel—A large square trowel used in rendering.
Lead Lights—Lights formed of small panes connected by lead cames.
Lead Safe—A tray of lead formed to catch any overflow water.
Levelling Rule—A rule used by plasterers in levelling ceilings.
Lignomur—A wall-hanging formed of wood fibre.
Lime and Hair—Another term for coarse stuff.
Lime Plaster—A term signifying that plaster is formed with lime.
Lime Putty—Pure lime run with water and allowed to settle.
Lime White—Chalk lime mixed with an excess of water, used as a wash.
Lincrusta Walton—A wall decoration executed in relief.
Litharge—Another term for oxide of lead.
Luxfer Glass—A special glass formed with prismatic projections on one side.

MACK PARTITION—A patent partition formed of plaster and reeds.
Mandrels—Cylinders of soft wood varying in length.
Margin Trowel—A parallel-sided trowel for plaster margins.
Massicot—A superior kind of oxide of lead.
Mastic—A resinous gum obtained from the Mediterranean.
Metallo-ceramic Joint—A patent joint for uniting lead pipe to earthenware.
Middling Lead Pipe—A pipe intermediate in weight between light and heavy.
Milled Lead—Sheet lead that has been rolled out.
Minium—Another name for red lead.
Mortise Lock—A lock that is inserted into a mortise formed in the thickness of a door.
Muffled Glass—Glass formed with a wavy surface.
Muffling—Covering a running mould with plaster to reduce its section.
Muffling Plate—A metal plate used to reduce the section of a running mould.
Muller—A kind of pestle used in grinding paint.
Muranese—A form of obscured glass.

NIB—The upper edge of a plasterer's running mould.
Nipple—The screwed end of gas pipe to receive the fitting.
Norfolk Thumb Latch—A latch operated by a lever which can be depressed by the thumb.

OIL POLISH—A finish produced with linseed oil.
Overflow—An outlet allowing water to escape on reaching its level.
Over Graining—A thin additional coat over ordinary graining.
Overcast Joint—One on which a series of facets are formed after wiping.
Oxide of Iron Paint—Paint in which oxide of iron forms the base.

PACKING PIECE—Iron slabs of various thickness used in levelling girders on stanchions.
Palette—A thin wooden board to receive paints used in decorative work.
Palette Knife—A long, flexible blade used in mixing up colours.
Painter's Torch—An apparatus for producing a flame for burning-off.
Pan Closet—An old form of w.c. in which a pan was employed to receive the contents.
Panel Float—A small float used for laying and smoothing work in panels.
Panel Trowel—Resembles a laying trowel, but is smaller.
Parian Cement—A white cement prepared from plaster of Paris and borax.
Parliament Hinge—A hinge having the form of an H.
Patent Size—A preparation of gelatine.
Pebble Dash—Another name for rough coat.
Pedestal Closet—A modern form of w.c. with basin and trap exposed to view.
Pivot—A projecting pin working in a socket.
Plaster of Paris—A fine white plaster prepared from gypsum.
Plate Glass—Glass poured hot on to a table and rolled out.
Pneumatic Bell—A bell operated by the compression of air.
Polished Plate—Plate glass that has been polished.
Polishing Trowel—A trowel used in finishing the setting coat of plaster.
Pot Metal—Glass which is coloured throughout its substance.
Pouring Stick—A short, grooved piece of wood to convey melted solder to the back of a joint.
Picking Up—Applying coarse stuff to walls, partitions, or cubings.
Priming—Covering a wood surface with the first coat of paint.
P-Trap—A trap the general form of which resembles a U.
Pulp Paper—The commonest class of wallpaper.

QUADRANT STAY—A stay bar for openings and arches having a quadrant form.
Quarries—Glass cut into small pieces for lead glazing.

RADIATOR—A closed metal vessel having a large superficial area for radiation.
Raglet—A chase cut in stonework to receive lead flashings.
Rain-water Gutter—A channel to receive rain-water from the caves of a building.
Rain-water Head—An open vessel above the pipe to receive the discharge from a gutter.
Rain-water Pipe—A metal pipe used to convey rain-water.
Red Lead—An oxide of lead, usually in the form of a red powder.
Reducing Pipe—One reduced from a larger to a smaller diameter.
Reflector—Reflecting surface used to alter the direction of rays of light.

Register Grate—One having a flap, or register, between the grate and the chimney.
Render—The process of laying coarse stuff or cement on solid walls or ceiling.
Return Pipe—That part of a circulating pipe between the highest level and the boiler.
Ribbon Joint—One in which a band of solder is formed round the joint.
R.I.J.—Abbreviation for rolled iron joist.
Rim Lock—A lock attached to the face of a door.
Rising Butts—Those that lift the door slightly as it opens.
Rising Main—The pipe taken up to supply a cistern.
Roll—The method of forming a longitudinal joint between two sheets of lead.
Rolled Plate—Plate glass that has been rolled to produce a fluted surface.
Rough Cast—A method of finishing exernal plaster with pebbles or shingle.
Rough Cast Plate—Cast plate rolled with a smooth roller.
R.S.J.—Abbreviation for rolled steel joist.
Rubber Cone—A union formed of rubber.
Rubbing Down—The process of rubbing each coat of painted work.
Rule—A strip of wood varying in size and form used in floating plaster.
Running Rule—Wood strips fixed as guides for running moulds.
Running Mould—Moulded profiles by means of which mouldings in plaster are formed.

SADDLE-BAR—A metal bar used to give support to lead lights.
Sanitary Paper—Wallpaper printed in oil colours and washable.
Sash Fastener—A metal catch to secure one sash to another.
Sash Lift—A metal hook or plate by which a sash is lifted.
Sash Tool—The brush used in painting sash-frames.
Sash Weight—Metal weights used to counterbalance the sash and its glass.
Satin Paper—Wallpaper having a polished, satin-like surface.
Scaglioler—A special form of coloured plaster used in imitation of marble.
Scouring—Working over plaster surfaces with a hand float.
Scratch—A tool used in scratching or scoring plaster surfaces to form a key.
Scratch Tools—Small tools of various shapes used in finishing plaster enrichments.
Screed—A strip of plaster laid as a guide for floating.
Seam Roller—A small roller used in smoothing the joints in paper-hanging.
Seamed Pipe—A lead pipe formed out of sheet lead with a soldered joint.
Setting—The process of laying and finishing the final plaster coat.
Setting Coat—The last coat in plastering, formed of fine stuff.
Service Pipe—A pipe conveying water from the supply to a fitting.
Sgraffito—Successive thin coats of coloured plaster incised and cut to give pictorial effects.
Shave Hook—A tool used in shaving lead-work.
Shaving—The process of removing a thin layer of lead to provide a bright surface.
Sheet Glass—Glass blown in the form of cylinders and afterwards flattened.
Shoe—The outlet of a rain-water pipe over a gulley.
Side-arm Roller—Resembles a seam roller, but will work close up to a projecting surface.
Silicate Cotton—A fibrous non-conducting material produced from iron slag.
Single-swing Bracket—A gas bracket having one movable arm.
Size—A liquid preparation of glue.
Size Kettle—A kettle with water jacket, in which size is melted.
Skimming Float—A large float used for laying setting stuff.
Slag Wool—See *silicate cotton.*
Slipper—The face of a running mould.
Slop Sink—A sink intended to receive bedroom slops.
Smoothing Roller—A broad roller used in paper-hanging.
Smudge—A preparation used by the plumber in soiling.
Snap Rivet—One formed with a spherical head.
Soakers—Sheets of lead inserted under slates or tiles, and turned up against a wall.
Soil—Another term for smudge.
Soiling—The process of covering with soil those parts of lead work to which solder is not required to adhere.
Soil Pipe—A pipe for conveying away the contents of w.c.'s.
Soldered Dot—A method of securing vertical lead sheets to woodwork or stone.
Soot Door—A small iron door and frame inserted in a smoke flue.
Sparge Pipe—A pipe arranged to distribute a discharge of water over a wide area.
Splash Stick—A small wood or iron stick used in upright soldered joints.
Sprig—A small metal brad used by glaziers.
Sprigging—Temporarily securing panes of glass with sprigs.
Stanchion—A perpendicular support under a girder.
Standing Waste—A waste pipe standing up within a cistern.
Stand Pipe—A vertical pipe fitted with a tap for drawing off water.
Stay Pipe—A metal bar used to secure a window when open.
Stencil—A pierced plate for painting designs that repeat.
Stepped Flashing—One cut to allow of the upper edge being turned into successive brick joints.
Step Setter—A tool used in forming stepped flashings.
Stiffeners—In built girders pieces of angle iron used to stiffen the web and flanges.
Stippling—Finishing a painted surface with the end of a paint-brush.
Stock—The backing for the profile plate in a running mould.
Stopcock—A valve used to shut off a supply.
Stopped End—A closed end to a rain-water pipe.
Stopping—The process of filling up small holes in woodwork or plaster.
S-trap—A trap the outlet of which is in the form of an S.
Strap—A narrow plate used in securing timber joints.
Strap Hinge—A hinge for heavy gates, fixed to them with iron straps.
Striking Plate—The metal plate into which the bolt of a lock is inserted.
Stucco—A somewhat vague term applied to several plastic mixtures.
Swan-neck—A bent pipe connecting a rain-water gutter and pipe.
Syphon Box—An apparatus used to collect water from gas supply.
Syphon Closet—One in which the contents are removed by syphonic action.

TACKY—The condition of paint or varnish which fails to dry properly.
Taft Joint—A wiped lead joint resembling in form a copper bit joint.
Tar Paint—A paint for iron formed with tar, lime and naphtha.
Tension Rod—An iron rod used in trussing timber beams.
Throat—In pipe-bending, the inner side of the lead.
Tie-rod—A metal rod replacing a tie-beam in a compound roof.
Tingle—A broad strip of stout lead used to hold down the edges of lead sheets.
Tinning—The process of covering a copper bit with solder.
T-iron—Iron rolled in the section of a T.
Toe—The lower end of the stock of a running mould.
Touch—A piece of tallow candle is used to touch lead surfaces after shaving.
T-piece—A form of union between two horizontal and one vertical tubes.
Traversing Rule—A rule used for forming screeds in gauged or setting stuff.
Trimming Knife—A knife used for trimming wallpapers.
Trowelled Face—A plaster face highly finished with a trowel.
Trumpet-mouth Waste—A waste pipe the mouth of which is enlarged like a trumpet.
Turnbuckle—A fastening of iron or brass turning on a pivot.
Turn Pin—Wood cones used for enlarging ends of lead pipes.
Tynecastle Canvas—A material moulded in relief on canvas for covering walls.

UNDERHAND JOINT—A wiped joint on a horizontal pipe.
Union—A screw joint to unite a pipe to a cistern or a lead and iron pipe.
Universal Joint—A ball-and-socket joint.
Upright Joint—A wiped joint on a vertical pipe.

VALLEY GUTTER—A gutter formed in the angle between two roofs.
Valve Closet—One in which the outlet of the basin is closed by a valve.
Vehicles—The liquid with which pigments are mixed to form paint.
Ventilating Stove—A stove provided with a hot-air chamber and air inlet.

WALL HOOK—An iron spike with a curved end that will grip a pipe.
Warning Pipe—One that gives notice by dripping when a cistern is full.
Washable Distemper—Material resembling distemper, but which may be washed.
Wash-down Closet—One in which the bottom of the pan is continued into the trap.
Wash-out Closet—One in which the contents of the pan are washed out into the trap.
Water Stain—A material used for altering the colour of woodwork.
Water Waste Preventer—A cistern using only a limited amount of water at each discharge.
Wax Moulds—Used by plasterers for casting enrichments.
Wax Polish—A glossy surface produced on wood with the aid of wax.
Web—The vertical member of an iron girder.
Weeping Pipe—A pipe which allows water to drip slowly.
Welted Joint—One in which two metal sheets are folded together to form a joint.
White Lead—A carbonate of lead, the base of many paints.
Whitewash—A mixture of whiting, water and double size.
Wired Glass—Glass in which wire netting is embedded.
Wiped Joint—A joint formed with solder by means of a cloth pad.

ZINC PAINT—A paint of which the base is zinc white.
Zinc White—An oxide of zinc.

NATURAL HISTORY

SEE ALSO BIOLOGY

ALBUMINOIDS—Complex substances chiefly of carbon, hydrogen, oxygen, sulphur, and, sometimes, phosphorus.
Ambulacrum—A groove in the star-fishes which lodges the tube-feet.
Ampulla—The swollen part of a semi-circular canal in the internal ear of vertebrates. Or a small sac connected with the tube-foot.
Atavism—The appearance of a trait unlike the immediate parents, but resembling a more remote ancestor.

BARB—One of the branches of a feather.
Biconcave—Hollow on both sides like the vertebra of a fish.
Bivalve—The shell of a mollusc when composed of two parts.
Blood-parasitism — A habit of some animals, such as the cuckoo, of placing their young with other parents.

CALYX—The outermost leaves of a flower.
Cephalopods — The cuttle-fishes, and their allies.
Cetacea—The order of mammals which includes the whales.
Cheiroptera—The order of mammals which includes the bats.
Chelonia—An order of reptiles which includes the tortoises.
Chordata—All animals which possess a notochord.
Chrysalis—The motionless pupa of butterflies and moths.
Chyle—The fluid which results from the action of digestion upon food.
Coccyx—The end of the spinal column.
Cœlom—The body cavity.
Colloid—Substances which do not readily pass through membrane pores.
Ctenoid—Term applied to certain fish scales with the hinder margins fringed.
Cycloid—A term applied to those scales of fishes which have a circular, or elliptical, outline with an even margin.

DECIDUOUS — Structures which are shed during the life of an organism.
Diphyodont — Applied to mammals which have two sets of teeth.

ELYTRA—A beetle's anterior wings.
Entomophilous—Flowers which are fertilised by insects.
Eozoic—The earliest geological period.

FLORA—The plants of any region.
Furculum—The "merrythought" bone of birds formed by the union of the two clavicles.

GANOID—Those scales in fish which have an inferior bony layer.
Gastrula—A term applied to that stage of the embryo which exhibits a double layer with mouth and digestive cavity.
Germinal disc—That part of the egg which develops into the embryo.
Gill-cover—The flap which overlaps the gill-slits in fishes.
Gonophore—A bud in which the egg cells, or sperms, are produced.

HETEROCERCAL — The unequally-lobed tail in fishes.
Hock—The ankle in a horse's hind limb.
Homocercal—Equally-lobed fish tails.

INFUSORIANS—A class of the protozoa.
Insectivora—An order of mammals.

KAINOZOIC—The most recent geological epoch.

LACERTILIA—The order of reptiles including the lizards.
Lepidoptera—Order of insects which includes butterflies and moths.

MAMMALIA—The class of vertebrates which suckle their young.
Mantle-cavity—The space in molluscs which contains the gill, and into which the excretory organs generally open.
Marsupials—An order of mammals.
Medusa—The egg-producing stage of a jelly-fish, usually free swimming.
Mesozoic—The geological epoch which preceded the kainozoic.
Mongrel—A cross between two varieties of the same species.
Monœcious — Those individuals in which the two sexes are united.
Monophyodont—Mammals which develop only one set of teeth.
Monotremes — The lowest order of mammals.
Morula—An embryonic stage in which the segmented ovum is not hollow, but solid.
Mule—A cross between a horse and an ass.
Muscle—A definitely shaped piece of flesh.
Mutualism — The association of two organisms for the benefit of both.

NAGANA—Fly sickness ; a fatal disease of horses caused by a parasite which is carried by the tsetse-fly.
Nearctic Region—The northern part of the New World.
Neuter—Having no fully developed sex.
Normal—Conforming to the ordinary standard.
Nucleated—Possessing a nucleus.
Nucleolus—A minute body inside a nucleus.
Nymph—The active pupa of certain insects ; the stage which hatches from the egg.

ODONTOPHORE—The masticating organ in molluscs and cuttle-fishes.
Operculum—The gill cover in many fishes, also the horny plate which closes the shell of some molluscs.
Opisthocœlous — Concave behind, as in some vertebræ.
Oriental region—Southern Asia, together with part of the East Indies, the Philippine Islands, and Formosa.
Otocyst—A vesicle filled with fluid containing some solid particles. A simple form of hearing apparatus, probably also a balancing organ.
Otolith—A hard substance inside the hearing organ.
Ovipositor—An organ at the hinder end of the body of a female insect by means of which holes are made in plants for reception of the eggs.
Ovule—The portion of a plant which becomes a seed after fertilisation.

PALÆONTOLOGY—The science which deals with fossils.
Perissodactyla — Hoofed quadrupeds which have an odd number (one or three) of toes.
Pineal body—A structure in the roof of the vertebrate brain which probably represents the remains of a dorsal eye in some reptiles.
Pinnate (or **Pennatiform**)—Feather-shaped.
Pisces—The class of fishes.
Pisiform—A small round wrist bone.
Placenta—The organ in the higher mammals which establishes the vascular connection between the mother and the fœtus ; the after-birth.
Placoid—Irregular, thick, bony scales, such as found in sharks and rays.
Pleura — Serous membrane covering lungs of air-breathing vertebrates.
Pollex—The innermost digit of the fore-limb—in man the thumb.
Procœlous—Concave in front, as in some vertebræ.
Proglottis—A segment, or joint, of a tape-worm.
Pronation—The act of turning the palm of the hand downwards.
Pyriform—Pear-shaped.

RAPTORES—The birds of prey.
Recapitulation—The repetition of the successive ancestral stages in the development of an organism.
Rennin—A ferment in the gastric juice which curdles milk.
Resemblance — General : a harmony with surroundings, causing the organism to be inconspicuous. It may be protective or aggressive, or both. Special : a likeness to some particular object in the environment.
Reticulum — A network ; the second division of the complex stomach of a ruminant.
Retractile—An organ which is capable of being drawn back.
Rodentia — An order of mammals, gnawers.
Rostrum—The suctorial organ formed by the appendages of the mouth in certain insects ; any kind of beak.
Rotifera—The wheel animalcules.
Rudimentary organ — A structure which is not fully developed.
Rumen—The first division, or paunch, of the complex stomach of a ruminant.
Rumination—Process of cud chewing.

SACRUM—The part of the backbone with which the pelvic arches unite.
Scolex—Embryonic stage of tape-worm.
Sessile—Not supported by any stalk.
Setæ—Bristles.
Spermaceti—Liquid fat obtained from the sperm whale, contained in a deep depression in the side of the skull.
Spinnerets—Small projections on the under side of the abdomen of spiders, on which silk glands open.
Spiracle—The apertures of the breathing tubes in insects ; also the single nostril, or blow-hole, of cetaceans.
Supination—The act of turning the palm of the hand upwards.
Suture—The line of union between two immovable parts, as in skull bones.
Swim-bladder—An outgrowth from the alimentary tube of some fishes.
Swimmerets—The limbs of crustaceans which are adapted for swimming.
Symmetry—Regularity of structure, which may be either radial or bilateral (having right and left sides).
Symphysis—The union of two bones in which there is very limited motion.

TÆNIA—An order of tapeworm.
Teleostei—The order of the bony fishes.
Tetradactyl—Having four digits.
Tortoise-shell—A product of the horny plates obtained from certain turtles.
Trichocyst—Minute rods found in some Infusorians which are projected from the outer layer of the body for defence.
Tunicata—The sea squirts.

UNIVALVE—The shell of a mollusc composed of only one piece, as in the snail.
Urostyle—The hindmost portion of the backbone of a frog.

WAMPUM—The shell money of the North American Indians.
Water-vascular system — An arrangement of tubes, as in star-fish, concerned with locomotion and respiration.

ZOOTOMY—The science of the anatomy of the lower animals.
Zymotic—A term applied to diseases which are contagious.

BACTERIOLOGY

ACID-FAST—A term applied to those organisms which retain stains even though treated by decolourising acid solutions.

Actinomycosis — A disease most common in cattle, especially in the jaws, caused by the actinomyces or ray fungus.

Ærobic—A term applied to micro-organisms which require oxygen to enable them to grow.

Agar-agar—A substance prepared from the roots of seaweeds, used to solidify the medium in which organisms are grown.

Agglutination—The phenomenon observed when organisms are placed in a serum prepared from an animal immunised against similar organisms. The organisms thus treated are observed to lose their motility, and become aggregated or "agglutinated" into clumps.

Agglutinins—Definite substances in a serum, which causes the phenomenon of agglutination.

Alexins—Substances present in normal blood serum, which help to confer natural resistance to infection.

Anærobic—A term applied to organisms which will not grow in the presence of air.

Anthrax—An infective disease caused by the anthrax bacillus; communicable to man, in whom it causes woolsorters' disease of the lungs; malignant pustule in the skin.

Anti-bacterial Serum—A preparation of blood serum from an animal, which is destructive to certain microbes.

Antitoxic—Having the power of antagonising toxin.

Antitoxic Serum—A preparation of the blood serum from an animal, which antagonises the poison or "toxin" of certain microbes (*e.g.*, anti-diphtheritic serum).

Antitoxin — A substance which antagonises a toxin.

Attenuation—The process by which the virulence of a microbe can be reduced.

BACILLUS—Literally a small rod; a term applied to many organisms, which are of that shape.

Bacteria—Literally rods; but used to refer to micro-organisms in general.

Bactericidal—Having the power of destroying bacteria.

Beggiatoa—A group of organisms composed of indistinctly articulated threads, containing sulphur granules.

Blood Serum—A nutrient medium in which organisms are grown.

CHEMIOTAXIS—The name applied to the attraction or repulsion exercised upon bacteria by chemical agents (positive and negative chemiotaxis respectively).

Chromogenic—A term applied to organisms which produce pigment.

Cilia—Minute protoplasmic threads attached to the sides or ends of organisms, by means of which they move.

Cladothrix—A group of organisms in which there is an appearance of branching, really due to two terminal cells lying side by side.

Clubs—Elongated, pear-shaped bodies seen at the periphery of a colony of the actinomycosis parasite.

Coccus—A round organism occurring either singly, in pairs, in fours, in chains, or in bunches.

Colony—The term applied to a number of organisms growing together.

Complement—A substance developed during the process of immunisation.

Culture—The name applied to the growth of one single species of microbe when artificially cultivated.

Cytolytic Sera—Sera which are destructive to cells.

DIPLOCOCCUS—A coccus occurring in pairs.

Disinfectant—Any substance which has the power of destroying the life of microbes.

Drying—One method employed to weaken the virulence of organisms.

EHRLICH'S SIDE-CHAIN THEORY—The term applied to the theory advanced by Ehrlich to account for the formation of antitoxins in the body.

Enhæmospores—Spores found in the blood (as in malaria).

Exhaltation—The increase of virulence of microbes; the converse of "attenuation."

Exotospores—Spores occurring in the body of the mosquito; a stage in the life cycle of the malaria parasite.

FACULTATIVE—A term applied to organisms which can live either with or without oxygen.

Farcy—A form of glanders, affecting the lymphatic vessels and glands.

Fever—An abnormal rise of body temperature, frequently caused by microbes or their toxins.

Fission—A process of multiplication in microbes.

Flagella — Delicate protoplasmic threads [see *cilia*].

GELATIN—A substance used to solidify nutrient media.

Gentian-Violet—A stain much used to demonstrate microbes.

Gram's Method—A process of staining which differentiates certain organisms from others.

HÆMAMŒBA MALARIÆ — The parasite of quartan fever in man.

Hæmamœba Vivax—The parasite of tertian fever in man.

Hæmolytic Serum—The blood serum of one animal which has the power to a certain extent of dissolving the red blood corpuscles of another animal of different species.

Hæmomenas Præcox—The parasite of malignant or aestivo-autumnal fever of man.

Hydrophobia—An infectious disease occurring chiefly among carnivora, especially in the dog and wolf; transmitted by bite.

IMMUNE BODIES—Substances developed during the process of immunisation.

Immunisation—The process of rendering an animal immune.

Immunity—That condition of an individual, an organ, or a tissue, in virtue of which it is enabled to resist infection either absolutely or partially. Immunity may be natural or inborn, or it may be artificial or acquired. According to the means used for the production of immunity, it is active or passive. Active immunity is obtained by injections of organisms either attenuated or in sub-lethal doses; or, secondly, by injection of their products or toxins. Passive immunity is the injection of the serum of one animal, highly immunised by active immunity, into another animal, the latter being thus rendered immune.

Incubator—An apparatus used to cultivate organisms which require constant warmth.

Inoculation—The injection into an animal of microbes or toxin by means of a hypodermic syringe. Also, a means of separating one organism from a mixture of organisms.

LEUCOCYTES—White blood corpuscles, which act as phagocytes—*i.e.*, they have the power of taking up microbes into their protoplasm.

Leucocytosis—An increase in the number of leucocytes.

Lysogenic Action—The destructive action of an anti-serum upon organisms. It is due to two substances—the immune body and the complement, or alexin [see above].

MACROPHAGES—Any cells larger than the small leucocytes which have the power of ingesting bacteria.

Mallein—A substance used to diagnose glanders, prepared from cultures of the glanders bacillus.

Micrococcus—A general term applied to any small round microbe.

Microphages—The smaller leucocytes which ingest bacteria.

Myelocytes—Cells in bone marrow from which leucocytes develop.

NITRIFYING BACTERIA—Bacteria in the soil which make nitrogen more available for plant nutrition by conversion of ammonia into nitrites and nitrates. Others take up free nitrogen from air, and combine it into compounds.

OPSONIC INDEX—A means of stating the power of opsonins. The opsonic index is the ratio of the bacilli ingested by leucocytes incubated in the patient's serum to those ingested by an equal number of leucocytes incubated under similar conditions in healthy serum. Thus for tubercle bacilli the opsonic indices of healthy persons may vary from 0·8 to 1·2; in tubercular patients it may be as low as 0·3 or as high as 1·8.

Opsonins—Substances contained in blood serum which act upon bacteria rendering them more easily eaten by leucocytes. (From Greek words meaning "prepared for being eaten.")

PASSAGE—The process of passing a microbe through the body of an animal for purposes of attenuation or isolation.

Pathogenic—Productive of disease.

Pfeiffer's Phenomenon—A destruction of organisms by lysogenic action [see above] due to a specific substance in the serum.

Protective Inoculation—The conferring of immunity by active methods.

Ptomaines—Substances containing nitrogen isolated from putrefying matter or from cultures of microbes.

RECEPTORS—The name given by Ehrlich to groups of atoms with affinity for certain foodstuffs.

Ricin—A vegetable poison (allied to bacterial toxin).

SARCINÆ — Coccus-like organisms which divide in three axes at right angles to one another, usually seen in cubes of eight.

Septicæmia—A condition in which microbes multiply within the blood stream, and give rise to symptoms of general poisoning without the production of abscesses.

Spirilla—Organisms which are in the shape of cylindrical, wavy, or spiral cells.

Staphylococcus — A coccus which occurs in clusters.

Sterilisation—The process of rendering any substance free from microbes.

Streptothrix—An organism consisting of a mass of filaments in which true branching occurs.

TETRAD—The occurrence of an organism in fours (Tetracoccus.)

Toxin—A bacterial product of poisonous action.

Tuberculin—A curative or diagnostic agent for tubercular affections, prepared from cultures of the tubercle bacillus.

UNIT OF IMMUNITY—The amount of antitoxic serum which will neutralise 100 times the minimum lethal dose of toxin, serum and toxin being mixed, diluted, and injected subcutaneously. A normal antitoxic serum is one of which 1 c.c. contains an immunity unit.

ELECTRICITY

ACCUMULATOR—A cell in which the energy stored as chemical energy can be re-converted at will into electrical energy.

Air-gap—The air-space between two poles of a magnet.

Alternating Current—An electrical current which reverses in direction of flow in a periodic manner.

Alternator—An electrical generator producing in its external circuit alternating currents.

Ammeter—An instrument which measures and indicates in amperes the rate of flow of an electric current.

Ampere—The unit of rate of flow of an electric current in the C.G.S. system of units.

Ampere-hour—The amount of electricity which passes along an electric circuit when one ampere flows for one hour.

Ampere-turn—The magnetic effect produced when a current of one ampere flows round one complete turn of wire.

Anode—In an electric cell, the metal through which the current enters.

Arc—A luminous electric discharge through a gas, in which the material of one or both of the electrodes is volatilised and takes part in conducting the electric current.

Armature—Generally the rotating part of a dynamo or motor, upon which the moving conductors are mounted.

Armature Core—The laminated steel stampings forming the body of the armature, in the slots of which the conductors are placed.

Asynchronous—The name given to an alternating current motor whose speed has no fixed relation to the periodicity of the supply.

Auto-transformer—A transformer so wound that part of the primary winding acts also as a secondary.

B—The number of magnetic lines per square centimetre of material, or, more briefly, the flux density.

Balancer—A motor generator or accumulator used to equalise the pressure on either side of a three-wire system.

Battery—A number of cells or condensers working together.

Board of Trade Unit—The standard unit of electric energy—1000 watts acting for one hour, or its equivalent.

Booster—A motor generator used to add a given pressure to an electrical circuit.

British Thermal Unit—The quantity of heat required to heat 1 lb. of water 1° Fahr.

CANDLE-POWER—A measure of the intensity of light in a given direction.

Cascade Connection—Connecting two induction motors so that the secondary of one is in series with the primary circuit of the other.

Cell—Usually a vessel containing suitable electrodes and an electrolyte for generating an electric current.

C.G.S. System of Units—The system of electrical units in general use, based on the centimetre, gramme, and second.

Characteristic Curve—A curve showing the relation between the speed and voltage of a dynamo or motor.

Choking Coil—A coil of wire so wound that its self-induction largely exceeds its electrical resistance.

Circuit Breaker—An apparatus, usually automatic, for breaking an electrical circuit.

Commutator—That part of an armature which ensures that, in the external circuit of a dynamo or motor, the current shall be continuous in direction of flow.

Compound Wound Dynamo—A dynamo having both series and shunt wound coils in the field magnet circuit.

Compound Wound Motor—A motor having both series and shunt wound coils in the field magnet circuit.

Condenser—An apparatus consisting of two layers of an electrical conductor separated by an electrical insulator.

Conductor—A substance allowing electricity to pass along with comparatively small loss.

Continuous Current—A current of electricity flowing along a conductor in one direction only.

Controller—An apparatus consisting of a number of switches and electrical resistances, used for regulating the speed of a motor.

Coulomb—The unit of electrical quantity in the C.G.S. system of units.

Current Density—The number of amperes flowing at a given time per unit area of conductor.

DEPOLARISER—A substance placed in a primary cell to prevent the collection of hydrogen gas on a kathode.

Diamagnetic—Having magnetic permeability value lower than that of air, which is taken as unity.

Dielectric—A substance having a very high electrical resistance.

Dielectric Capacity—The relative high resistance of so-called insulating bodies as compared with air.

Distributing Board—A board on which a number of electrical switches or fuses, or both, are placed.

Diversity Factor—The number obtained by dividing the sum of the maximum loads of the individual consumers of an electricity supply system, during a given time, by the maximum load on the station during the same period.

Dry Cell—A primary cell in which the electrolyte is in the form of a colloid or jelly, and that consequently is unspillable.

Dynamo—A machine for converting a mechanical motion into electrical energy (continuous current), by means of a conductor moving in a magnetic field.

Dynamometer—An electric dynamometer is an instrument for measuring electrical forces by the action on each other of two coils carrying the current to be measured.

EARTH-PLATE—The ground connectors of a lightning-rod, usually a copper plate immersed in damp earth.

Efficiency—The ratio of work done to the work expended in doing it.

Electric Bell—A bell actuated by an electric current, usually from a distant point.

Electric Circuit—A continuous line of electric conductors, along which a current of electricity can flow.

Electric Current—The name given to the electrical activity of an electric circuit when a difference of electrical pressure exists between varying points in the circuit.

Electrode—An electrical conductor terminating in an electrolyte.

Electrolysis—Chemical decomposition caused by the passage of an electric current through an electrolyte.

Electrolyte—A liquid which, when acted upon by an electric current, undergoes decomposition.

Electromagnet—A magnet, consisting usually of a soft iron core, which is magnetic only so long as an electric current flows round the exciting surrounding coil.

Electromotive Force—The force which tends to send an electric current flowing through an electric circuit.

Electron—The atomic quantity of electricity which, associated with an atom of matter, is called an ion.

Electrostatic Field—The name given to the space surrounding a charged electrical conductor, in which electrical action is induced by the charge on the conductor.

Enclosed Fuse—A thin piece of fusible wire placed in a glass, china, or cartridge case.

Ether—See *Luminiferous Ether*,

FARAD—The unit of electrical capacity in the C.G.S. system of units.

Feeder—A cable or pair of cables in an electrical distributing system which run, untapped, from the generating station to the feeding point.

Ferraris Field—The rotating magnetic field of an induction motor.

Field Magnet—The name given to the magnet poles of a dynamo or motor.

Flame Arc Lamp—An arc lamp in which the greater part of the light comes from the flame and not from the electrodes.

Foot-candle—The illumination obtained at a foot distance with a source of light of one candle-power.

Fuse—A thin fusible wire, inserted in an electric circuit to melt, and so break the circuit, before any other part of the circuit is damaged.

GALVANOMETER—An instrument for measuring small electric currents.

Gauss—The unit of magnetic force in the C.G.S. system of units.

Glow Lamp—An electric lamp in which the light is produced by the incandescence of an electrical conductor.

H—The number of magnetic lines per square centimetre there would be in air; or, more briefly, the intensity of the magnetising force.

Henry—The practical unit of the coefficient of self-duction or mutual induction in the C.G.S. system of units.

Horse-power—The industrial unit of power. In this country it is equivalent to 33,000 foot-pounds per minute, or, in electrical units, 746 watts.

Hysteresis Loss—The power dissipated in iron by reason of magnetic hysteresis.

IMPEDANCE—The apparent resistance, composed of actual resistance and self-induction, which determines the flow of current in an alternating current circuit.

Induced Current—A current produced in a closed electric circuit by the action of a current of varying strength in an adjacent electrical circuit.

Induction—The action, either magnetic or electric, produced in bodies by adjacent, but not touching, magnets, electric circuits, or charged electrical bodies.

Induction Motor—An alternating current motor in which the current in the rotating part is produced by electromagnetic induction.

Inductive Load—An apparent load in an electric circuit greater than the real load by reason of the self-induction of the circuit.

Insulation Resistance—The electrical resistance of the insulation between two conductors, or between one insulated conductor and earth.

Insulator—A substance offering a high resistance to the passage of an electric current.

Interpoles—Small extra magnetic poles in a dynamo or motor, introduced to reduce the sparking at the commutator with varying load.

Inverted Arcs—Arc lamps arranged so that all the light is reflected towards the ceiling and no direct rays reach the observer.

Ion—An atom of matter combined with an electron.

JOULE—The unit of work done in an electrical circuit in one second in the C.G.S. system of units.

Joule's Law—The law relating the heat produced in an electrical circuit to the current flowing in the circuit.

KATHODE—In an electric cell, the metal through which the current leaves the cell.

Kilowatt—The name given to 1000 watts, a convenient unit of electrical power.

LAGGING CURRENTS—An alternating current flowing in a circuit later than its corresponding electrical pressure.

Leading Current—An alternating electric current flowing in a circuit in advance of its corresponding electrical pressure.

Leakage Coefficient—That proportion of the magnetic flux of dynamos and motors which does not pass through the armature, but leaks across by some other path.

Lightning Arrester—An appliance for protecting an electric circuit from the effects of lightning.

Lightning-rod—A copper rod placed on buildings to protect them from lightning.

Load Factor—The ratio between the energy used in an electrical circuit in a given time to the maximum load operating for the same period.

Luminiferous Ether—The name given to the substance pervading space and the interstices of all bodies, vibrations in which convey light, heat, and electricity.

μ—The symbol used for the magnetic permeability of a substance.

Magnet—A substance possessing the property of attracting magnetic substances and producing magnetic fields.

Magnetic Blow-out—An appliance using an electromagnetic field for the purpose of extinguishing an electric arc.

Magnetic Field—The space surrounding a magnet through which magnetic action is transmitted.

Magnetic Flux—The number of magnetic lines of force passing through a given area.

Magnetic Flux Density—The number of magnetic lines of force per square centimetre.

Magnetic Hysteresis—The tendency by which magnetic changes lag behind the magnetic forces causing them, the overcoming of which causes loss.

Magnetic Induction—The production of a magnet by the proximity to it of another magnet.

Magnetic Lines of Force—The imaginary lines along which magnetic action is transmitted.

Magnetic Permeability—The numerical coefficient expressing the ratio between flux density (**B**) and magnetising force (**H**).

Magnet Pole—Those parts of a magnet in which the power to produce magnetic effects are concentrated.

Maximum Demand System—A system of charging for electric energy dependent to a large extent on the maximum amount of power taken.

Maxwell—The unit of magnetic induction in the C.G.S. system of units.

Mesh Winding—A method of connecting the phases of a polyphase circuit so that, together, they form a closed circuit without any common neutral point.

Microfarad—The name given to one-millionth part of a farad.

Microphone—An apparatus for electrically magnifying minute sounds.

Milking Booster—A low pressure dynamo, usually motor-driven, used to charge single cells in an accumulator battery.

Motor Generator—Two electrical machines, either alternating or direct current, or one of each, rigidly coupled together, one acting as motor and the other as generator.

Motor Starter—A special switch and resistance used to protect the motor on starting.

NON-INDUCTIVE LOAD—A load on an electric circuit in which there is no apparent increase due to self-induction.

OHM—The unit of electrical resistance of units in the C.G.S. system of units.

Ohmmeter—An instrument which measures and indicates the resistance in ohms of an electric circuit.

Ohm's Law—The law expressing the relation of the rate of flow of current in an electrical circuit to the electrical pressure and the resistance.

PERIODICITY—The number of complete cycles of change which an alternating current makes in one second.

Permanent Magnet — A substance (usually steel) which, having been magnetised, retains its magnetic properties.

Polarisation—The reduction of effective electrical pressure in a primary cell, caused by the generation of gases at the electrodes.

Potentiometer — An instrument for measuring electrical resistances by balancing a current against a known fall of electrical pressure.

Power Factor—The ratio in an alternating current circuit between the real load and the apparent load.

Primary Cell—A cell containing an electrolyte and suitable electrodes for obtaining an electric current through a closed external electric circuit.

RATIO OF TRANSFORMATION—The ratio of the number of turns on the primary and secondary windings of a transformer.

Rectifier—An apparatus for converting alternating into direct currents.

Relay—An apparatus for opening or closing a circuit controlled by the current in another circuit.

Remote Control—Appliances for opening or closing electrical circuits at distant points.

Residual Magnetism—The small magnetic strength left in an electromagnet after the current has been switched off.

Resistance—The property of a body retarding the flow of an electric current through it.

Retentivity—The magnetic force needed to overcome the residual magnetism of a substance.

Rheostat—An easily adjusted electrical resistance.

Rotary Convertor—A dynamo having a commutator at one side of the armature and slip rings connected at special points to the armature winding, at the other. Used for converting alternating into direct currents.

Rotor—The rotating part of an induction motor having an independent electrical circuit.

SELF-INDUCTION — The inductive effect exercised upon an alternating electric circuit by itself.

Series Dynamo—A dynamo having both field and armature circuits wound in series with each other.

Series Motor—A motor having both field and armature circuits wound in series with each other.

Shunt—The name given to an electrical circuit which is connected in parallel to another electrical circuit.

Shunt Dynamo—A dynamo having the field circuits wound in shunt with the armature circuit.

Shunt Motor—A motor having the field circuits wound in shunt with the armature circuit.

Silver Voltameter—An electrolytic cell in which a silver salt is the electrolyte.

Single Phase—The name given to a single alternating current circuit.

Slip—The difference between the actual and theoretically definite speed of a synchronous motor.

Slip Ring Rotor—A rotor having slip rings through which the induced current may, at starting, be taken to an external resistance.

Solenoid—A coil of wire forming part of an electric circuit, used for producing a magnetic field.

Squirrel-cage Rotor—A rotor having the electrical winding simply short-circuited on itself.

Stalloy—A steel alloy containing a small quantity of silicon, and much used for dynamo, motor, and transformer stampings.

Star Winding—A method of connecting the phases of a polyphase circuit so that these meet at a neutral point.

Stator—The fixed part of an induction motor, through the winding of which the primary current flows.

Synchronous Motor—An alternating current motor whose speed bears an approximate relationship to the periodicity of the circuit on which it is used.

THERMOPILE—A number of couples of suitable metals, connected to give the maximum thermo-electric effect.

Three Phase—An alternating current circuit, usually of three wires, in which three alternating currents flow, having a phase displacement of 120°.

Tractive Effort—The torque or turning moment of an electric motor.

Transformer—An apparatus consisting of two electrical windings, usually independent of each other, together with an iron core, used for changing the voltage of an alternating current.

Tungsten Lamp—An electric glow-lamp having a very thin wire or thread of tungsten for the filament.

Two Phase—An alternating current circuit, usually of four wires, in which two alternating currents are flowing, having a phase displacement of 90°.

VOLT—The unit of electrical pressure in the C.G.S. system of units.

Voltmeter—An instrument which measures and indicates in volts the electrical pressure between any two points of an electrical circuit.

WATT—The unit of electrical power in the C.G.S. system of units.

Watt Hour—The electrical power expended when one watt operates for one hour, or its equivalent.

Watt Hour Meter—An instrument fitted with an integrating mechanism, for measuring watt hours or the energy sold to an electricity consumer.

Wattless Current—That part of an electric current flowing through an inductive alternating circuit which is not doing any useful electric work.

Watt Meter—An instrument which measures and indicates in watts the electrical power being expended in an electrical circuit at any moment.

Weston Standard Cell—A primary cell, using cadmium as one electrode, used as a standard for obtaining electrical pressure.

Wheatstone Bridge—An instrument for measuring electrical resistances by balancing them against other known electrical resistances.

THE TEXTILE TRADES

ABASSI—A whitish Egyptian cotton.
Absorbent Cotton—Bleached fibre made from linters (*q.v.*)
Alpaca—Hair of Peruvian lama.
Amazon—An all-wool dress stuff.
Angola—Yarn of mixed woollen and cotton.
Angora—Goat, producer of mohair.
Astrachan—Curled pile fabric.
Axminster—Tufted carpet.

B. A. WOOL—From Buenos Aires.
Baft—An export calico, white or blue.
Bannockburns—Tweeds from twist yarn.
Bast—Fibres from under the bark of plants.
Beam—Large roller to carry warp yarn.
Beatrice—Weft twill, 4 up and 1 down.
Beaver—Heavy woollen cloth, fine face, smooth back.
Beer—Warp threads grouped for convenience.
Beetles—Machines to hammer fabric.
Bleaching—Whitening cotton or linen by chemical or other means.
Bleeding—The "running" of colours.
Blends—Mixtures of loose fibres.
Block-printed—From flat blocks, not cylinders.
Blowing-room—Room in which raw cotton is opened and freed from dust.
Bobbins—Yarn carriers, usually double-ended.
Botany—Australian merino wool.
Bowl—Heavy rollers in cloth finishing.
Box-looms—Working more than one shuttle.
Breech—Wool of the coarest growth.
Brocades—Jacquard-figured satins.
Brussels—Loop-pile carpet.
Bump—Extremely coarse cotton yarn.
Bundles—Parcels of yarn, usually 10 lb.
Bunting—Flag cloth, worsted or cotton.
Burling—Removing minor defects in cloth.
Burr—Spines of weed often present in wool.

CABOTS—Grey cotton sheetings.
Calendering—Cloth-pressing between rollers.
Calico—Plain-woven cottons.
Cambric—Plain, fine cottons or linens.
Camelhair—Produce of bactrian camel.
Cap-spun—Worsted spun on cap spindles.
Cape Wool—South African.
Carbonising—Eliminating vegetable matter by use of acids.
Card-clothing—Fabric furnished with wire teeth for covering the cylinder of carding machines.
Carding—Preparing fibre for spinning by means of fine wire teeth.
Cashmere—(1) Hair of Kashmir goat; (2) twilled dress goods of merino wool or merino and cotton; (3) used to signify high-class worsted.
Chain—Synonym for warp.
Chardonnet Silk—Artificial silk, nitrated cellulose.
Cheeses—Yarn cross-wound on tubes.
Chenille—Fabric woven from fringe.
Cheviot—Synonym for crossbred. Strictly, wool from Cheviot sheep.
Chevron—Herringbone pattern.
China Grass—Hand-stripped ramie fibre.
Chlorination—Process to render hosiery unshrinkable.
Cleaning Waste—Prepared cotton thread waste.
Clothing Wool—Too short for the woolcomb.
Coatings—Men's worsteds.
Codilla—Scutchers' tow.
Coir—Coconut fibre.
Comb—Machine for removing shorter fibres.
Condenser—Forms sliver from web delivered from carding engine.
Condition—Proportion of moisture present.
Cop—Paper tube for carrying yarn.
Corkscrews—Fine warp twills.
Counts—Yarn numbers indicating fineness.
Crabbing—Treating to prevent shrinkage in course of dyeing.
Crape—Crimped fabric.
Creel—Frame for holding yarn bobbins.
Crinoline—Stiffening-cloth, horsehair, and cotton.
Crossbred—Wool from sheep of crossed merino strain.
Cross-dyes—Effects obtained on mixed fabrics, the wool dyed one colour and the pattern another.
Crowns—Grades of flax.
Cuttling—Folding cloth in plaits.

DECATISING—Treating woollens with dry steam.
De-gumming—Removing gum from silk or ramie.
Delaine—Light worsted for printing.
Denier—Denotes fineness of silk.
Derby Doubler—Forms laps from cotton sliver.
Designing—Planning out fabrics.
Devil—Disintegrating machine for rags.
Dhooties—Cotton loin-cloths, bordered.
Diagonals—Cloths with pronounced diagonal rib.
Discharge-effects—Produced by removing colour previously applied.
Dobby—Modification of the jacquard.
Doctors—Scrapers fixed on printing machines.
Doeskin—Superfine woollen, soft finished.
Doffers—Remove bobbins from spindles, or fibres from rollers.
Donskoi—South Russian wool.
Double-spun—Cotton yarn cleared of defects.
Double-warp—The warp of two-fold yarn.
Doubling—Converting single into two-fold yarn.
Down Wool—From sheep of Downs breed.
Draft—Ratio in which sliver is decreased in course of drawing.
Drawing—The reduction of sliver.
Drill—Cottons or linens warp-twilled.
Dry-spun—Wool spun without oil. Linen spun without water.
Duck—Canvas.
Duvetyn—Smooth finish produced by emery rollers.

EGYPTIAN—Brownish cotton from Egypt.
Elastic Web—Tape with rubber threads in warp.
End—(1) A thread of warp; (2) a short length of cord.
Extract—Wool fibre recovered by carbonisation.

FANCIES—Goods of diversified character; distinct from plains.
Fearnought—Strong-toothed opening machine.
Fellmongers—Dealers in skin wool.
Felt—Fabric formed by interlocking loose fibres.
Fents—Remnants of cloth.
Filature—Silk-reeling factory.
Fingering—Yarn for hand-knitting.
Flannel—All-wool fabric.
Flannelette—Soft cotton fabric.
Flax—Raw material of linen.
Floats—Unintersected threads on the surface of fabrics.
Flocks—By-products in raising, shearing, or milling cloths.
Floorcloth—Oilcloth.
Fly Waste—Fluff.
Flyer-spun—Yarn from fly spindles.
Frames—Machines.
Frieze—Rough woollen cloth.
Frog—Part of cotton loom.
Fustian—Heavy cotton cloth.

GALATEAS—Striped and coloured cloth.
Galoons—Hat ribbons.
Garnetts—Machines with saw teeth for opening twisted fibres.
Gassed Yarn—Singed free of protruding fibres.
Gauze—Light fabrics with adjoining warp threads crossed.
Gauze-points—Constants used in calculating drafts in spinning.
Gilling—A straightening process practised upon long fibre.
Gin—Machine for removing cotton from its seed.
Gingham—Checked cottons for aprons, etc.
Grandrelle—Hard-twisted yarn, strands of separate colours.
Grant-reeled—Hanks of cross-wound yarn.
Grasscloth—Chinese native manufacture from ramie.
Greys—Goods unbleached or undyed.
Gunclub—A double-check design.
Gun-cotton—Nitrated cotton or cotton-waste.
Gunnies—Jute bagging cloth.

HACKLE—A flax-comb.
Half-bred—English wool from crossed breeds of sheep.
Hank—Standard measure of yarn.
Hard Waste—Thread waste.
Harris Tweed—Made in Harris, Hebrides.
Harvards—Coloured shirtings, 2-and-2 twill.
Heald—(Heddle.) Apparatus for lifting warp threads in weaving.
Hedge—Protective sale or purchase.
Hessian—Packing canvas.
Hoggets—First-shear sheep and wool.
Hopsack—Basket weave; weaving two threads plain instead of one.
Horsehair—Tail and mane hair.
Humidifiers—Atmospheric moisteners.
Hydro-extractor—Centrifugal dryer.

ICELAND WOOL—Fine, silky wool of Icelandic origin.
Indian Cotton—British East Indian growth.
Indigo-dyed—Containing some indigo, natural or synthetic.
Italians—Sateen linings, cotton or worsted and cotton.

JACK FRAMES—For drawing cotton rovings exceptionally fine.
Jacks—Knitting-machine bars.
Jaconet—A form of cambric.
Jacquard—Appliance for weaving figures.
Jeans—Cotton twills for linings.
Jigger—A dyeing machine.
Joanovitch—A silky Egyptian cotton.
Jobs—Imperfect goods.

KEMPS—Opaque wool fibre.
Khaki—A brown-green shade.
Kibizzos—Japanese waste silk.
Kidder Carpets—Cloth carpets.
Kier—Bleaching vat.
Knicker Effects—Coloured flakes or lumps present in yarn.
Knotless Yarn—Spliced at its joinings.
Knubs—Silk reelers' waste.

Lappets—Cloth with extra warp figures woven on the surface.
Laps—Sliver rolled in layers.
Lastings—Made for boot-tops, corsets, etc.
Leas—Parts of a hank.
Lenos—Gauzes with open patterning.
Levers' Lace—Made on Levers' machines.
Line—Linen.
Lingos—Weights for jacquard cords.
Linters—Fibre remaining on the cotton seed after ginning.
Lisle—Hard-twisted cotton yarn.
List—A selvedge.

London-shrunk—Fully shrunk woollens.
Longcloth—Calico for under-garments
Loom—Weaving machine.
Lump—A double-length piece.
Lustre Wool—Lincoln and Leicester wools.

M. V. WOOL—Shipped from Monte Video.
Manufacturer—Producer of cloth.
Maranham—A Brazilian cotton.
Marine Fibre—Poseidonia Australis.
Market Whites—Fully bleached cotton pieces.
Mauds—Rugs.
Mays—An irregular twill weave.
Melange—Sliver-printed.
Meltons—Woollens with raised and cut surface.
Mending—Inserting dropped threads in cloth.
Mercerised—Treated with caustic alkali.
Merino—(1) Wool of the merino sheep; (2) Blended wool and cotton hosiery; (3) Dress goods of merino wool.
Metallics—Prints ornamented with metal dust.
Metric Count—496 yards per lb.
Middling—Standard American cotton.
Milling—A process for consolidating wool cloths.
Mitafifi—Normal Egyptian cotton.
Mixture—Mixed colourings, without regular patterns.
Mohair—Fleece of Angora goat.
Moires—Watered patterns.
Mordant—Agent in fixing colours upon fibre.
Mule—Intermittent spinning machine.
Mulls—Fine muslin.
Mungo—Short fibre from milled woollen rags.

NAINSOOK—Light, soft cotton fabric.
Naps—Heavy woollens with a raised and rubbed surface.
Neat Silk—Thrown silk.
Nep—Little balls of fibre formed by twisting around the teeth of combs or cards.
Net—A loop fabric.
Noble Comb—Circular wool-combing machine.
Noils—By-product of combing.
Northrop—Loom with automatic replenishing of weft.

OOZE—Slubs in cotton yarn.
Open-Band—Yarn-twist running clockwise.
Opening—Loosening out fibres.
Operative—A millhand.
Organzine—Thrown silk for use as warp.
Orleans—Cotton shipped from New Orleans.
Overcheck—A large check superimposed on smaller ones.

PACK—240 lb. of wool, tops or yarn.
Padding—Dyeing cotton with rollers and a shallow trough.
Paper Yarn—Twisted paper.
Paramattas—Union wool goods for waterproofing.
Pattern—Sample of cloth. Synonym also for design.
Pectose—Vegetable wax.
Perching—Cloth-examining over rollers.
Peruvian—Rough cotton used to mix with wool.
Pick—A weft thread.
Picking Strap—Communicates motion to shuttle.
Piece—Standard length of fabric, varying in different goods.
Piece-dyed—Dyed after weaving.
Pile—Erect surface of loops cut or uncut, or of raised fibres.
Piques—Cottons ribbed warpwise.
Pirns—Bobbins unprotected at ends.
Pitch—Number of warp threads in 27 in. of carpet.
Plains—Fabrics without fancy features.
Plaiting—Cloth-folding.
Plate Wools—Shipped from the River Plate.
Plush—Long cut-piled fabrics.
Point Paper—Squared for designers' use.
Poplins—Cloth ribbed in weft direction.
Porcupine—Spiked roller.
Port Philip—Fine Australian wool.
Preparing—Making ready.
Press—Hydraulic or other for flattening.
Prints—Cloth printed.
Proofing—Rain or water proofing.
Prunella—A warp twill, 2-and-1.

RABBETH—Type of spindle.
Race-board—Part of loom.
Rag Flock—Generated in grinding woollen rags.
Raising—Scratching up fibre on the surface of cloth.
Ramie—A nettle fibre.
Ratch—The distance separating front and back rollers of spinning machinery.
Raw Silk—Reeled, but not thrown.
Re-combing—Twice combing.
Reed—Beating-up wires in the loom.
Reel—Arms for winding yarn in skein.
Regain—Percentage of natural moisture.
Repeat—Recurrence of design.
Repps—Fabrics ribbed weftwise.
Resists—Applied to prevent the taking of colour in places.
Retting—Fermentation process to loosen flax from the straw.
Ring-spun—Yarn from ring frames.
Rovings—Soft threads ready to become yarn.

SAKEL (Sakellaridis)—A long, fine Egyptian cotton.
Satins—Weaves concealing the intersection of the threads.
Saxony—Merino wool.
Schappe—Continental waste-silk yarn.
Schreinering—Embossing cloth with exceedingly fine lines.
Scotch Tweed—All-wool, Scottish-made.
Scouring—Washing.
Scroop—A slight crackling experienced on handling.
Scutching—Beating flax straw to remove fibre.
Sea Island—The longest and silkiest cotton.
Serges—Twilled woollens or worsteds.
Sericin—Silk gum.
Sett—Warp threads in given width of cloth.
Shade—The precise colour.
Shafts—Healds.
Shearing—(1) Wool-clipping; (2) Cropping the surface of cloth.
Shed—The parting formed between warp threads for the traverse of the shuttle.
Sheeting—Stout, wide calico.
Shive—Woody matter adhering to the fibre.
Shoddy—Long-stapled woollen waste.
Shoot—Synonym for weft.
Shot—A pick of weft.
Shuttle—Weft-carrier in loom.
Singles—Yarn of one strand.
Sinkage—Weight lost in working materials.
Size—Mucilage used on yarns.
Skin Wool—Removed from slaughtered animals.
Slasher—A sizing machine.
Slay—Part of loom carrying the reed.
Slazy—Cloth too bare, showing the structure.
Slipe—Skin wool removed by liming.
Sliver—Fibre in soft, continuous rope or ribbon.
Slubbing—Sliver lightly twisted.
Slubs—Thick places in yarn.
Smallwares—Tapes, braids, and narrow goods generally.
Snarls—Kinks in yarn.
Soft Waste—Without twist.
Solid Colour—Not a mixture colouring.
Spindle—Rotating rod around which yarn is spun.
Spinner—A producer of yarn.
Splits—Goods woven two or more in width and then cut.
Spool—A form of bobbin.
Spun Silk—Spun silk waste.
Staple—The length of fibres.
Stapled Americans—Mississippi long-fibred cotton.
Stenter—See Tenter.
Stoving—Bleaching woollens in sulphur fumes.
String—Denotes damaged place in cloth.
Strips—Cotton carding waste.
Stuffs—Dress fabrics.
Surats—Raw cotton from Bombay Presidency.
Surgical Cotton—Prepared lint.

TABBY—Plain cloth.
Tambour—Embroidered stitching.
Tapestry Carpet—Design printed, not woven.
Tappets—Cams to lift healds.
T Cloth—Common grey calico.
Tear—Ratio of top to noil.
Teazle—Thistle-head used in finishing woollens.
Teg—See Hogget.
Tender—Not strong enough.
Tenters—Frames for drying and stretching cloth.
Terry—Cloth with loop pile.
Thrums—Piece ends.
Tod—28 lb. weight.
Tops—Combed wool.
Tow—Flax combings.
Tram—Silk weft.
Tropicals—Worsteds for tropical wear.
Tsatlees—Hand-reeled China silk.
Tussah—Uncultivated silk.
Tweeds—Fancy woollens.
Twill—Diagonal woven rib.
Twiner—Mule doubling machine.
Twist—Cotton yarn for warp.
Twisting-in—Attaching ends of one warp to another.

UNIONS—Cloths having warp and weft of different materials.
Uplands—American cotton from the Southern uplands.

VAT DYES—Fast colours, developed on the fibre.
Velvet—Silks with erect warp-pile.
Velveteen—Cottons with erect weft-pile.
Venetians—Satteen warp twills.
Vicuna—Usually soft woollen cloth.
Viscose—Artificial silk from wood-pulp.
Voile—Open structure woven from hard-twisted yarn.

WARP—Longitudinal threads in cloth.
Washed Wool—Washed on the animal's back.
Waste—By-products utilisable for re-manufacture.
Waste Silk—Unreelable silk.
Weft—Transverse threads in cloth.
Weft-fork—Stop-motion on loom.
Wether Wool—Wool from two-year or older sheep.
Whipcords—Stable tweeds.
Wigans—Heavy cotton twills.
Willow—Machine for cleaning and opening fibres.
Wilton—Carpet with Brussels loops cut.
Winding—Passing yarn from hank or bobbin to bobbin.
Woof—Archaic term for weft.
Wool-dyed—Dyed in the loose.
Woollen—Yarn in which the wool fibres are intercrossed.
Wool-sorting—Dividing fleece into qualities.
Worsted—Yarn of parallel wool fibres.

YARN—Fibres bound together by twisting.
Yarn-dyed—Dyed in the yarn stage.

ZEPHYRS—Fancy cottons.

THE LEATHER TRADES

AGEING—Hanging skins that are being tawed for gloves to dry, the process occupying about a month.
Alkaline Soaking—Soaking hides in solutions of caustic soda or crystallised sodium sulphide in order to soften them.
Aluming—Preparing leather for belt laces, whip lashes, etc., by impregnating skins with alum and salt solution.
Annatto—Dye from the arnotto plant, used in currying.

BACK-STRAP—A thin leather strip inside a seam to protect it.
Bating—Steeping hides in a solution of hen or pigeon dung to render them soft and fit for tanning. See *Puering*.
Bazils—Sheepskins tanned in oak or larch bark.
Beading—The insertion of a thin double strip between two other pieces of leather so as to show the folded edge of the insertion.
Beam-house—The part of a tannery in which unhairing is done.
Belly—The part of a skin or hide that covers the belly of an animal; also, in saddlery, a piece of leather fixed to the hind pommel for the attachment of valise straps.
Bespoke—Boots or shoes which are made to order.
Bevel—The skive of a piece of leather.
Blocking—The process of wetting leather and pulling to a given shape, as in making Wellingtons.
Bloom—A whitish deposit on the grain side of leather during immersion in bark liquors.
Bottom sizing—Treating waxed leather, after blacking, with a preparation of glue and tallow.
Bottom Stuff—The leather used for soles and heels of shoes.
Bottom Width—The widest part of the fore part of a last.
Box-calf—Calfskin chrome tanned and usually grained.
Box Toe—The toe of an upper raised and stiffened during lasting; not often done now.
Brads—Square-topped nails used for boot heels.
Breeching—The part of a horse's harness that passes round the breech and enables it to back a vehicle.
Bristling—Affixing bristles to wax thread for sewing leather, as in bootmaking.
Buckskin—Leather, properly prepared from deerskins, but now often made from sheepskins.
Buffing—Scraping with a steel scraper until smooth. This is done to skins in currying, and also to soles in bootmaking.
Buff-stick—A flat piece of wood with emery one side and kid the other, used to sharpen a clicker's knives.
Button-fly—The part of a boot that has the buttonholes.
Butt—A hide of sole leather with the belly and shoulders cut away; the best part of the hide.

CALF KID—A dull-faced, soft leather tanned by alum, but now almost obsolete.
Calf Patent—Calfskins stretched and enamelled on the flesh side.
Cank—To extend a skin, during setting, with a steel sleaker.
Catechol—The tannin principle extracted from catechu, giving greenblacks with iron salts.
Catechu—Tanning material extracted from wood of the acacia, catechu, and other trees.
Caveson—A leather noseband for breaking in a horse.
Chamois—A soft leather made from the flesh-split of sheepskins by oil-dressing.
Chape—In saddlery, a metal protection for the end of a strap or belt.
Chrome-calf—Skins of calves dressed by the mineral chrome process.
Clicker—A man who cuts out shoe uppers.
Clinkers—Wrought-iron nails used for heavy boots.
Closing—Putting together the various parts of shoe uppers.
Clump—A thick sole nailed on to a boot the sole of which has worn down.
Collagen—The gelatine-producing substance which constitutes the fibre of the skin.
Consolidated Laster—An ingenious machine that lasts up boots and shoes at a very rapid rate.
Cordovan—Skins of goats and dogs, and occasionally of hogs, tanned in liquor of extract of oak bark or extract of sumac, and afterwards rubbed with oil of sesame.
Corium—The true skin; the part used to make leather.
Counter—The stiffener used at the back of a boot or shoe, made of leather, cardboard, or canvas, and placed in position between the upper and the lining.
Creasing—Forming a line for ornament down each side of a strap.
Crown Leather—Lace-leathers produced by drumming hides with fat and flour.
Crupper—A leather strap buckled to the back of a saddle, with a loop at the other end passing under the horse's tail.
Crust Stock—Skins which, after tanning, are oiled, dried out, and stored ready for finishing.
Currying—To prepare tanned hides for use by soaking, scouring, colouring, and other processes.

DELIMING—A process to remove the lime from skins.
Depilation—Removing the hair from the skin previous to tanning.
Derbies—Boots with the outside quarter cut to a point which is placed over the vamp, as in shooting-boots.
Dextrine—A gummy substance used for sticking together greasy leathers.
Divi divi—The pod of a tropical leguminous plant yielding tannin when boiled.
Drafting—Altering the curve of a portion of a boot to ensure a tension at that part to oppose any strain put upon it during wear.
Draft-plan—The outline of the foot made by pencilling round it.
Drenching—Soaking hides and stirring in a fermenting bran infusion.
Dried Hides—See *Flint Hides*.
Drum Stuffing—Rotating wet leather in a barrel or drum heated by steam or hot air, and then introducing hot grease, with which the skins become impregnated.
Dubbing—A preparation of grease used in currying.

EDGE TRIMMING—Trimming the edges of a sole preparatory to finishing.
Ellagic Acid—A white crystallised deposit found in leather, treated by the iron-blueing tannins.
Erodin—An artificial deliming agent used in tanning, consisting of gelatinous matter, peptonised by heating with acid, with the addition of phosphates.
Eyeletter—A machine for placing the eyelets in lace boots and shoes.
FACINGS—The inside strip of leather placed under or over the edge of the boot where the eyelets are, and used to support the strain caused in lacing the boot.
Fat-liquoring—Drumming skins, previously freed from an excess of water, in a weak emulsion of oil and soap to make them soft.
Feather—The reduction of the edge of an insole to prevent it curling or hurting the wearer's foot.
Fellmongering—Removing the wool from sheep and lamb skins.
Finishing—The process of knifing, rasping, sandpapering, inking, ironing, and burnishing the edges and bottoms of boots.
Fittings—The inside parts of a boot or shoe, such as topbands, facings, straps, and linings; also the pieces of leather or gutta percha used to make up parts of lasts to the required size; also different widths of a given size.
Flesh—The under portion of leather, that which on the animal comes next to the flesh; usually distinguished by a rough appearance.
Fleshing—Removing the bits of flesh, etc., from the back of a skin before tanning.
Fleshing Knife—A blunt, two-handled knife used in fleshing.
Flint Hides—Hides dried in the sun to preserve them for tanning. They become exceedingly hard; hence the name.
Forewale—The smaller roll of a horse-collar.
Fresh Hide—One taken recently from the slaughtered animal.
Frizing—Scraping the grain surface of a skin with a sharp two-handled knife on the beam.

GAMBIER—Same as *Catechu*.
Glacé Kid—Kidskins alumed and rubbed with a lustre of wax and oil, then ironed, and polished a second time.
Glassing—Rubbing waxed skins on the flesh side, after blacking, with a thick smooth glass slicker to smooth and brighten them.
Glazed Kid—American chrome kid glazed by friction under a smooth glass cylinder.
Glazing Machine—A machine for glazing American chrome kid.
Glove Kid—Skins, usually from the kid, but sometimes from the lamb, dressed by the tawing process. They are soft and supple, but spoilt by wetting.
Glucose—A sweet compound used in the basic chrome process.
Golosh—The whole-cut vamp; also an overshoe.
Grading—Passing shoe soles through a machine that sorts them according to thickness.
Grain—The top part of a skin of leather that comes nearest the epidermis, and from which the hair has been removed.
Graining—To soften and raise the grain of a skin.
Green Hide—Same as Fresh Hide.
Grounding—Scraping the flesh side of a skin with a moon knife after the skin has been dyed.

HALF SOLING—Putting a new half sole on a boot, after cutting away the part of the old one that is worn away from the toe to the waist.
Hand-sewn—The method of making a boot by hand, that consists of sewing a welt with the upper to the insole, and then afterwards stitching the outer sole to the welt.

Hauling—Drawing skins from the lime-pits, where they are placed for unhairing.
Head Knife—A heavy two-edged blade of soft steel, held by handles attached to a bar down the centre. It is used for shaving or splitting.
Head Stall—The part of a bridle that goes round the head.
Heel Builder.—A machine for building up heels lift by lift.
Heel-measure—The distance round the foot at the sharp bend in the front and round the heel.
Heel Parer—A machine for cutting the built heel to the proper shape.
Heel Plate—A metal plate on the seat of some lasts, enabling the heel to be nailed on, the plate clinching the nails.
Heel Shave—A hand tool for shaping the heel after it is built up on the boot.
Hide Mill—A machine which softens dried hides by hammering.
Hides—Skins from the backs of the larger animals, such as oxen, buffaloes, and the like.
Hinged Last—A last sawn in two, with the parts hinged together, so as to be easily drawn from a boot.
Horsing—Raising or lowering the upper at the seat when pulling it over the toe of the last.
Hyaline Layer—The thin membrane between the epidermis and the corium.
Hydrolysis—Decomposition by the action of water of the chemical compounds formed by the action of the acids of a hide with lime.

INSOLE—The inner sole of a boot, to which the upper is attached.

JIGGER—A shoemaker's tool which is used to set the welt and face of the stitch.

KERATIN—The horny tissue that forms the epidermis.
Kino—Tanning material extracted from the Indian kino-tree and other allied plants.
Kip—The skin of a small or young animal, such as a lamb or calf.
Knifing—Shaping the edges of boots to prepare them for burnishing.

LANGTRY—A design of shoe with a rounded latchet front.
Last—The model, of wood or iron, on which the boot or shoe is built up.
Laster—The man who stretches the upper round the last and attaches it with tacks to the insole. Also a machine that does this work.
Last-fitter—The man who takes a stock-shaped last and makes it up with fittings and filing to the required shape of a foot.
Last-spring—The rise or upward curve of the toe of a last.
Latchet—The tab of the front portion of the quarter of a Derby or tie-shoe.
Leaching—Preparing tannin from bark by soaking and draining.
Levant—Term used for leather with a pebbly grain like levant morocco, frequently used in bookbinding. Such leather originally came from the Levant.
Lifting or Lifts—The pieces of leather used to build up a heel.
Limepit—Pits, containing lime water, in which the hair of skins is loosened.
Liming—The process of steeping skins in lime water to loosen the hair and outside skin.
Lines of Tightness—The directions in which a skin draws tight when subjected to a pulling strain. The observance of them in cutting out is important.
Link Belt—A belt for transmitting power, made up of a number of detachable leather links.
Logwood—A colour, obtained from the logwood tree, often used in dyeing leathers.
Long Work—Boots that reach to the calf, or higher.
Looping—Making and decorating the various kinds of leather loops used in harness.

MACHINE-SEWN—Term used for boots in which the uppers, insoles, and soles are sewn together at one operation by a sole-sewing machine.
Machine-welted—Term used for a boot made on the principle of a hand-sewn boot, but with the welt and sole machine-sewn.
Mangrove Extract—One of the cheapest forms of tannin, obtained from mangrove bark.
Martingale—A strap passing between a horse's fore legs, and fastened to the girth beneath the belly and at the other end to the bit.
Memel Calf—A skin dressed on the grain side and boarded to give a fine grain.
Mimosa Bark—A material, yielding tannin, obtained from various species of acacia.
Mineral Tanning—Tanning performed with chemicals in place of vegetable tans, as in chrome leathers.
Moon Knife—A knife with a turned edge and a horizontal handle at the lower part, used in grounding.
Mordanting—Treating skins with a substance known as a mordant to fix the colour of a dye.
Morocco—Leather made properly from goatskins and tanned with sumac, but now frequently made from sheepskins.
Myrobalans—Tannins obtained from the pulp surrounding the kernel of the fruit of several Indian trees of the species Terminalia.

NAPPA LEATHER—An American oil-leather made by fulling with soft-soap.
Native Hides—Hides from home slaughter.
Neutralising—Washing chrome leather in a weak alkaline liquor to fix the chrome salt absorbed by the hide.
Non-tannins—Sugars and other carbohydrates fermented by bacteria and yeasts to organic acids, which, while they do not tan, are partly absorbed by the hide.

OAK-BARK—The oldest of all tanning materials, but now not often used exclusively.
Oakwood—The wood of the oak from which tannin is extracted. It is obtained from waste wood and sawdust.
Offal—The inferior portions of the hide, such as the belly, the cheeks, and the faces.
Ooze Calf—A soft chromed leather with a pebbly grain and fine velvety back.

PADDLE VAT—A tank containing a revolving wheel, used for tanning, washing, and colouring skins.
Paraffin Wax—A mineral oil used in drum-stuffing.
Parchment—The skin of sheep or goats prepared by mechanical processes for writing upon.
Paste-fitting—Sticking together the various parts of the upper of a boot prior to machine-stitching them together.
Patent—A leather with an enamelled surface, so called because the process was originally patented.
Pegged—Term used for boots the soles of which have been attached to the uppers with small wooden pegs.
Pelt—The skin of a small animal with the hair on it.
Perching—Fixing a skin to a bar after dyeing and stretching it with a tool.
Pickling—A process that by the use of salt and acid preserves the pelt for tanning.
Pinholes—Small faults, caused by burst blisters, that occur in skins if they are drenched too long.
Pitch—The provision in a last to accommodate the height of the heel.
Pommel—A piece of hard wood, grooved and strapped to the hand, used for graining leather and rendering it supple.
Porpoise—Leather made from the skin of the porpoise. It is very durable and tough.
Pounding up—Cutting away the bunched upper on the insole after lasting, and taking out any creases in the upper. This is done by machinery.
Pricker—See *Stitch-pricker*.
Puering—Steeping hides in a solution of dog-dung. See *Baiting*.
Puff—The small piece of skived leather placed under the toe of an upper to preserve the shape when lasted.
Puff Toe—Same as *Box Toe*.
Pulling Over—The stretching of an upper to the last preparatory to lasting.
Pulling-over Machine—A machine that pulls over the upper ready for the consolidated laster.
Punching Machine—A machine for punching the holes in boots for eyelets.
Pulling out—Freeing skins from water on a table with a blunt knife, prior to fat-liquoring them.
Pyrogallol—Tannins giving blue-blacks, and often used as inks.
Quarters—The back part of a boot or shoe.
Quebracho—A tannin extracted from the bark of a South American tree.

RACING RANGE—A strip cut from a butt of sole leather.
Ranging—Dividing a butt into ranges.
Raw Edge—The edge of a piece of leather that is laid over another without being turned in.
Raw Hide—Leather used for belts and laces, prepared by a combination of fat and vegetable tanning.
Reds—A dark brown substance deposited on leather by iron-greening tannins.
Rhatany—The root of a Peruvian plant from which tanning materials are extracted.
Riveting—Fastening the outer soles of boots to the inner soles by brass rivets; frequently used in cheap repairing.
Roans—Sheepskins with a grained face, used for linings, and also for bookbindings.
Rolling—Hardening leather by passing it between heavy rollers.
Rounding—Cutting away the outer edges of a hide.
Roundings—The poorer parts of leather thrown out when cutting up skins; the edges or skirting of skins.
Rounding Knife—The knife used in rounding.
Rounding Table—A table on which a hide is laid for rounding.
Russet-calf—The calfskin in the crust before it has been curried or blackened.
Russia Leather—Goat or sheep leather dressed with a brown birch or larch oil, which gives it a fragrant odour, and protects it from the ravages of insects.

SALTED HIDES—Hides from South America, preserved with salt.

Samming—Piling up hides after their removal from the tanpits and allowing them to stand, so as to soften by the fermentative heat.

Satin-calf—Calfskin dressed in the grain, but finely buffed to a smooth face.

Satin-hide—The split hide of the buffalo, with the grain buffed to a very fine face.

Scale—A range of sizes and fittings suitable for lasts.

Scudding—Removing remaining hairs, dirt, etc., from a hide or skin with a knife after depilation.

Scouring—Removing the bloom and smoothing the hides after they have been tanned; also smoothing the soles or heels of boots preparatory to finishing.

Scouring-machine—A machine for scouring hides; also a machine for scouring the soles and heels of boots and shoes.

Scouring-stone—A tool with two sharp edges, used in hand scouring.

Seasoning—A liquid, such as a weak solution of egg—or blood—albumen with a little milk and dye, used for slightly moistening dyed skins that have been dried, preparatory to glazing.

Seat—The portion of the boot immediately over the heel. In hand-sewn boots the seats are either pegged or sewn.

Second-lasting—Placing a turnshoe on the last a second time, after it has been sewn and turned, in order to shape it.

Sectional Lasts—Lasts made in several pieces to facilitate withdrawal from the boots when lasting has been completed.

Setting—A process that has to be carried out rapidly. The grain side is first well worked out on a flat table with a stock stone, and the flesh side then canked.

Sew Round—A shoe that is made inside out, the inseam being placed all round the sole and upper.

Shagreen—A peculiar kind of parchment prepared from the skins of the horse, ass, and camel. There is also a fish shagreen.

Shank—The waist or narrowest part of the sole of a boot.

Shoulder—The fine and tough part of a skin that formerly covered the animal's shoulder.

Shover—A leather fitting made to go down the front of a last to increase its measurement.

Sidespring—A boot with elastic gussets at each side.

Size Stick—An instrument used by the bootmaker in measuring the lengths of feet.

Sizing—Treating waxed leathers with a size made of glue and tallow after blacking.

Skin—A hide from one of the smaller variety of animals.

Skive—To bevel or reduce the edges of leather to allow one portion to lap over another.

Slabs—Under-splits of leathers cut into two or more sections.

Sleaker—A flat steel blade with a square edge, set in a wooden backing, that is grasped in both hands; used in hand scouring.

Sleaking—Using the sleaker.

Slicker—Same as *Sleaker.*

Soaking—The preliminary operation of tanning, which consists in washing away the dirt, blood, or salt in water.

Sole-sewer—The machine that sews upper, insole, and outer sole together in a machine-sewn boot.

Split—The flesh portion of a split hide.

Split Lift—A strip of leather nailed round the seat of a boot before the heel is put on.

Splitting—Dividing skins into two separate layers, as in splitting sheepskins, when the grain side is made into imitation morocco or roan, and the flesh side into chamois leather.

Staking—The process of drawing a skin over a blunt edge to stretch it and make it soft.

Standard—The first pattern for uppers of a series of sizes. Other sizes are made from the standards.

Starching—Treating butts with a glue-and-water solution previous to graining.

Stiffener—Same as *Counter.*

Stitch-pricker—An awl used to mark holes for stitching in leather, to ensure regularity.

Stocking—Softening hides in a hide mill.

Stocks—Same as *Hide Mill.*

Stoning—Sleaking butts with a stone sleaker after whitening during the currying operations.

Straights—Lasts in which the right and left feet are alike, and not specially shaped.

Stretch—The give of a leather when pulled.

Striking—Removing the bloom with a striking pin during the finishing of sole leather, a process now often performed by a machine.

Striking Pin—A two-handled tool of triangular form with three blunt edges. A butt is thrown across a beam or horse, and the workman stretches and smoothes the grain side with the striking pin.

Stuffing—Forcing fats and waxes into leather during currying. It is done by hand or by drumming.

Suède—Undressed kid which has been fluffed on the grain side with a fine rotating wheel.

Sumac—A product of the dried leaves of the sumac tree, used for tanning light-coloured leathers.

Surcingle—A girth passing round the body of a horse to keep in place a blanket or rug.

Suspenders—Contrivances for suspending hides in the tanning liquors.

Sweating—Depilation brought about by slow decomposition.

Sweat Pits—Stone or brick structures, above ground, protected from the sun's rays, in which hides are placed for sweating.

Synthetic Tannins—Coal-tar products, possessing many of the properties of natural tannins and producing very white and soft leathers.

TANNATE—A salt of tannic acid, such as tannate of iron, potassium tannate, etc.

Tanner's Beam—A convex sloping table of wood or iron, over which a hide or skin is thrown by the tanner so that he may scrape off the hair.

Tannic Acid—Same as *Tannin.*

Tannin—The astringent property found in many vegetable products, chiefly extracted from barks and seed pods and the like

Tanning Drum—A revolving drum in which hides are tanned.

Tanning Extracts—Concentrated preparations of various kinds of bark or other vegetable material.

Tannometer—A hydrometer for showing the proportion of tannin in a tanning liquor.

Tan-ooze—A watery extract of tanbark.

Tan-pickle—The liquor of a tan-pit.

Tan-press—A machine that squeezes the moisture out of wet spent tan.

Tawing—Making raw hides or skins into leather without the use of tannin, by treating them with alum, salt, or fatty products.

Throat-band—The throat-latch of a bridle—that is, the strap that passes under the horse's neck and holds the bridle in place.

Throat-strap—The upper strap of a halter, which passes round the horse's neck.

Tips—Metal fittings of horseshoe shape that are fastened to the heels of boots to save the leather.

Tongue—The leather strip that is arranged up the front of the foot beneath the eyelet holes in a lace boot or shoe.

Top-bands—The pieces of leather inside the top edges of boots.

Top-piece—The top lift of a heel.

Tops—Same as *Uppers.*

Top-sizing—A somewhat similar operation to bottom-sizing, which it follows.

Trace—The strap by which a vehicle is drawn.

Tucking—The process of shrinking oil-dressed hides by dipping them in hot soda solutions.

Tumbler—A stuffing drum.

Turning-in—The edge of leather folded under so as to show a smooth, rounded edge.

Turnshoe—A shoe that is made inside out with an insole, and afterwards turned.

UNDERLAY—The portion of leather that goes under the lap of a seam.

Unhairing—Removing the hair from a skin.

Unhairing Beam—See *Tanner's Beam.*

Unhairing Knife—A two-handled iron scraper used in unhairing.

Uppers—The portion of the boot that covers the upper part of the foot; that is, all the boot but the sole and heel.

VALONIA—The cup of a large acorn obtained from a species of oak that grows in the Near East. From it tannin is extracted.

Vamp—The front portion of a shoe.

Vatting—Washing leather, after tanning, in a warm, strong solution of bleaching extract contained in a vat. This is done in order to make the colour brighter.

Vellum—The skin of goats, kids, or calves prepared for writing or printing by exposure in lime and repeated rubbings.

WAIST—The narrow or middle part of the sole of a boot.

Wash-wheel—A revolving drum in which hides or skins are washed before tanning.

Wax-calf—The skin of the calf, tanned, curried, and blackened on the flesh side.

Waxing—Producing a deep, glossy black on leather, usually by the use of lamp-black and cod-oil or soap solution.

Weak Grain—A defect caused by too great putrefaction during unhairing, which results in a much less glossy surface.

Wellingtons—Long boots with side seams from top to bottom.

Welt—A strip of leather sewn round the boot, connecting insole and upper with the strip, to which the outer sole is then sewn.

Welted Work—Boots with welts.

Whitening—In currying, removing surplus grease from a skin with a slicker that has a turned edge.

White Whale—A leather freqently sold as porpoise, to which it is much inferior.

Wing—The part of the vamp that runs into the waist.

Winkers—The blinders or blinkers of a horse's harness.

ASTRONOMY

AEROLITE—A meteor which falls to the earth's surface.
Albireo—A double star in Cygnus.
Alcor—Star in Ursa Major.
Aldebaran—Brightest star in Taurus.
Algol—A variable star in Perseus.
Alphard—Brightest star in Hydra.
Altair—Brightest star in Aquila.
Altazimuth—Simplest telescope stand.
Altitude—Height of heavenly body from horizon in angular measurement.
Andromeda—A northern constellation.
Annular Eclipse—When eclipsed sun appears as a ring of light.
Ansa—The space between the ring and globe of Saturn.
Antares—Brightest star in Scorpio.
Aperture—Breadth of a telescope's object-glass, or principal mirror.
Aphelion—A planet's furthest distance from the sun.
Apogee—A planet's furthest distance from the earth.
Arc—A portion of a circumference.
Arcturus—Brightest star in Boötes.
Argo—A southern constellation.
Asteroid—See *planetoid*.
Auriga—A northern constellation.
Axis—The imaginary line on which a heavenly body rotates.
Azimuth—Angular distance of a heavenly body measured horizontally.

BELLATRIX—A star in Orion.
Betelgeuse—A variable star in Orion.
Bode's Law—An empirical arrangement of the planetary distances.
Bolide—A species of shooting star.
Boötes—A northern constellation.

CANIS MAJOR AND MINOR—Two southern constellations.
Canopus—Brightest star in Argo.
Capella—Brightest star in Auriga.
Cassiopeia—A northern constellation.
Castor—A bright binary star in Gemini.
Cepheus—A northern constellation.
Charles's Wain—Portion of Ursa Major.
Colure—Imaginary circle of the celestial sphere.
Comes (Comeez)—The small companion in a double star.
Comets—Gaseous bodies moving through the solar system.
Conjunction—Two or more heavenly bodies apparently near one another.
Constellation—An artificial grouping of stars by map-makers.
Co-ordinate—Elements which determine the position of a body.
Cor Caroli—Brightest star in Canes Venatici.
Corona—The sun's atmosphere.
Culmination—The meridian passage of a body.
Cusps—The extremities of a crescent, as the moon.
Cygnus—A northern constellation.

DEGREE (°)—A celestial measure, the 360th part of a circle.
Demos—One of the satellites of Mars.
Deneb—The brightest star in Cygnus.
Digit—The twelfth part of the sun or moon's diameter.
Draco—A northern constellation.

EARTHSHINE—Faint glow on unillumined part of crescent moon.
Eccentricity—The distance of a focus from the centre of an ellipse.
Eclipse—Obscuration of one heavenly body by another, or by its shadow.
Ecliptic—Sun's apparent annual path.
Egress—The passing of one body off the disc of another.
Ellipse—Shape of a planetary orbit.
Elongation—The angular distance of Mercury or Venus from the sun.
Emersion—The reappearance of a body after eclipse or occultation.
Encéladus—One of Saturn's satellites.
Epoch—Time to which calculations regarding heavenly bodies are referred.
Equation of Time—The difference between true and mean solar time.
Equator—Imaginary line running round the celestial sphere midway between the Poles.
Equinoxes—Those portions of the year when day and night are equal.
Eros—A minor planet between the earth and Mars.

FACULÆ—Bright markings on the solar disc.
Finder—Small telescope attached to larger to facilitate object finding.
Fomalhaut—The brightest star in the constellation Piscis Australis.
Fraunhofer Lines—Dark lines in the spectrum discovered by Fraunhofer.

GALAXY—The Milky Way.
Gegenschein—A luminous appearance resembling the zodiacal light.
Gibbous—A phase nearly approaching "full."
Gravity—Mutual attraction of bodies.
Gyroscope—An instrument for demonstrating the earth's rotation.

HELIACAL—Rising same time as the sun.
Heliometer—An instrument for measuring small angular distances.
Heliostat—Instrument for counteracting apparent motion of the sun.
Hercules—A northern constellation.
Hour Angle—Distance of heavenly body from meridian in hours, etc.
Hyperbola—Form of cometary orbit.

IAPETUS—One of Saturn's satellites.
Immersion—Disappearance of an object during eclipse or occultation.
Inclination—The angle made by an orbit to the ecliptic.
Inferior Conjunction—When an inferior planet approaches nearest to the sun on earth's side.
Inferior Planets—Mercury and Venus.
Ingress—The beginning of transit of one heavenly body across another.

JUNO—A minor planet.
Jupiter—The largest planet of the solar system.

KEPLER'S LAWS—The laws of planetary motions, enunciated by Kepler.

LATITUDE—The angular distance of a body from the ecliptic.
Leonids—Annual shower of shooting stars occurring about November 14.
Libration—An apparent oscillation of the moon.
Limb—Apparent edge of a heavenly body
Longitude—Angular distance of a body from the first point of Aries.
Lyra—A northern constellation.

MAGELLANIC CLOUDS—Two nebulous objects in south hemisphere.
Markab—Brightest star in Pegasus.
Mars—Planet between the earth and Jupiter.
Mercury—The innermost planet of the solar system.
Meridian—A line drawn through the heavens from north to south.
Meteor—A shooting star.
Micrometer—An instrument for making celestial measurements.
Milky Way—A belt of minute stars spanning the heavens.
Mira—A variable star in Cetus.
Mizar—A star in Ursa Major.
Motion Direct—Advancing in the order of the zodiacal signs.
Motion Retrograde—Advancing contrary to order of zodiacal signs.

NADIR—The point opposite the zenith.
Nebula—A gaseous mass in the heavens.
Neptune—The outermost planet of the solar system.
Nodes—Points where an orbit crosses the ecliptic.
Nutation—An oscillation of the earth's axis.

OCCULTATION—The hiding of a star or planet by the moon.
Opposition—When a planet crosses the meridian at midnight.
Orion—A well-known constellation.

PALLAS—A minor planet.
Parabola—Form of cometary orbit.
Parallax—An apparent shift in the place of an object.
Penumbra—The dull edge of a shadow.
Pegasus—A northern constellation.
Perigee—Nearest the earth.
Perihelion—Nearest the sun.
Perseus—A northern constellation.
Perturbation—The influence of one body on the path of another.
Phobos—A satellite of Mars.
Photosphere—The sun's visible surface.
Planetoid—A minor planet revolving between Mars and Jupiter.
Pleiades—Star group in Taurus.
Pollux—Bright star in Gemini.
Præsepe—Star group in Cancer.
Precession—A slight retrograde motion of the equinoxes.
Procyon—Bright star in Canis Minor.
Prominences—Outbursts of incandescent vapour seen at the solar limb.

REGULUS—Brightest star in Leo.
Refractor—A telescope with an object-glass.
Reflector—A telescope with a mirror in lieu of object-glass.
Rigel—Bright star in Orion.
Rill—A cleft on the moon's surface.
Rotation—Period an object takes to turn on its axis.

SATELLITE—Attendant body; a moon.
Saturn—A planet between Jupiter and Uranus.
Selenography—The study of the moon's surface.
Sickle—The front portion of Leo.
Sirius—The brightest star in the sky, in Canis Major.
Solstices—Points where the sun is northernmost or southernmost.
Southern Cross—A brilliant star group near the South Pole.
Southing—Crossing the meridian.
Spectroscope—Instrument for analysing light.
Spectrum—Analysed light.
Spica—Brightest star in Virgo.
Sun—The centre of the solar system.
Superior Conjunction—When a body approaches nearest to the sun on opposite side from the earth.
Superior Planet—A planet remoter from the sun than the earth.
Synodic—The time which a planet takes to return to the same position with respect to the sun and earth.

TELESCOPE—An instrument for bringing distant objects apparently nearer.
Terminator—The line separating day and night on the moon or a planet.
Titan—Saturn's largest moon.
Transit—Passage of a body across the meridian or a larger body.

UMBRA—Earth's shadow in a lunar eclipse; centre of a sun-spot.
Uranus—A planet of the solar system between Saturn and Neptune.
Ursa Major—A northern constellation.

VARIABLE STARS—Stars whose light varies in intensity.
Vega—Bright star in Lyra.
Venus—Planet between Mercury and the earth.
Vesta—One of the minor planets.

ZENITH—The point exactly overhead.
Zodiac—That portion of the sky through which the sun and other bodies of the solar system move. The Signs of the Zodiac (not identical with the constellations of the same name) are:—Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricornus, Aquarius, Pisces.

GEOLOGY

SEE ALSO MINING AND "THE WORLD'S MINERALS" ON PAGES 3999-4014

ÆOLIAN, or AERIAL DEPOSITS—Those produced by the action of atmospheric agencies.
Amorphous—Without definite structure.
Anticline—A tilting of strata into an arch.
Aqueous Deposits—Deposits due to the action of water.
Archæan—The most ancient rocks.
Arenaceous Rocks—Sandy rocks.
Argillaceous Rocks—Clayey rocks.
Atmosphere—The gaseous envelope surrounding a planet.
Axis—The line about which a crystal or other structure displays symmetry.

BEDDING—The arrangement of rocks in layers or bedding planes.
Boss—A mass of volcanic rock pushed up to the surface.
Boulder Clay—A stiff clay full of stones and boulders, left by glacial action.

CAINOZOIC—The period of recent life.
Cambrian — The oldest Primary system.
Calcareous—Limy rocks.
Carbonaceous—Coal-bearing rocks, or those containing carbon.
Carboniferous—The fourth Primary system, including the coal measures.
Catastrophe, or Cataclysm—A convulsion of Nature which causes great and sudden geological changes.
Cleavage—The division of a rock into layers, due to pressure.
Clinometer—An instrument for measuring the slope of strata.
Colloid—A jelly-like, non-crystalline mineral structure.
Conformable—Strata laid down regularly on one another.
Contour Line—A line drawn through a series of points at the same height on a map.
Crater—The basin into which a volcanic vent opens.
Cretaceous—The latest Secondary system.
Crystalline Minerals or Rocks—Those consisting of crystals, or symmetrical structures produced by cooling or precipitation.
Crust—The upper solid portion of the earth.

DÉBRIS, or DETRITUS—The remains of rocks broken down by erosion or denudation.
Denudation—The wearing away of rock by natural agencies.
Derivative Rocks—Rocks produced by some modification of an older rock.
Devitrification—The loss of glassy characteristics, due to weathering.
Devonian, or Old Red Sandstone—The third Primary system.
Dip—The slope of strata from the horizontal.
Dislocation—A fracture in rocks accompanied by disunion of the strata.
Dyke—A vertical seam of volcanic rock, usually found standing up like a wall.

EARTHQUAKE—A rapid movement of the earth's surface.
Eocene—The oldest Tertiary system.
Epigene—Above the surface of the earth.
Erratic Blocks—Boulders transported by glaciers.
Erosion—Wearing away of rocks by natural agencies.

FAULT—A dislocation.
Fissure—A crack in rock formations.
Fluviatile—Pertaining to rivers.
Foliation—A leaf-like structure in certain minerals.
Fossil—The remains of a plant or animal preserved in stratified rocks.
Fossiliferous Rocks—Rocks which contain fossils.

GEOLOGY—The science of the earth.
Geyser—An intermittent fountain of heated water.
Glaciation—The action of glaciers on rocks.
Glacier—A river of ice.
Grey Wethers—Blocks of Eocene sandstone, known in Wiltshire as Druid stones.

HADE—The angle of a dislocation to the vertical.
Hydrosphere—The watery envelope partly surrounding the earth.
Hypogene—Subterranean.

IGNEOUS ROCKS—Those formed by the action of heat.
Impermeable—Through which water cannot penetrate.
Intrusive Rock—A rock forced through an older formation.

JOINTS—Natural divisions in rocks, usually more or less vertical.
Jurassic — The middle Secondary system.

LACUSTRINE—Pertaining to a lake.
Lagoon—A salt water lake connected with the sea.
Lake—A body of fresh or salt water entirely surrounded by land.
Lamina—A thin plate.
Lithosphere—The solid globe of the earth.
Loam—A fertile soil, consisting of clay and sand with a mixture of organic matter.

MAGMA—The viscous liquid from which the igneous rocks solidified.
Marine—Pertaining to the sea.
Marl—A calcareous clay.
Matrix—The general body of a rock in which other substances are embedded.
Mesozoic—The middle period of life on the earth.
Metamorphic Rocks—Those which have been modified by heat, pressure, or chemical action.
Mineral—A chemical element or inorganic compound of which rocks are formed.
Mineralogy—The science of minerals.
Miocene—The third Tertiary system.
Moraine—The accumulation of earthy and stony matter left by a glacier.

NEBULA—A celestial body composed of gas or of a cloud of meteorites—the raw material of stars and planets.
Neck—The solidified pipe of lava of an extinct volcano.
Neozoic—The period of recent life.

OLIGOCENE—The second Tertiary system.
Outcrop—The part of a rock stratum which emerges on the earth's surface.

PALÆOZOIC—The period of most ancient life.
Permeable—Through which water can pass.
Permian — The youngest Primary system.
Petrography—The science of rocks.
Planes—The roughly parallel divisions of rocks caused by cleavage, stratification, etc.
Pleistocene—The glacial or older Quaternary system.
Pliocene — The youngest Tertiary system.
Post-Glacial—The Human Period.
Plutonic Rocks—Those igneous rocks which have taken shape below the earth's surface.
Pre-Cambrian—The oldest system of stratified rocks.
Primary Rocks—The second oldest of the five main divisions of stratified rocks.

QUATERNARY—The most recent stratified rocks.

RIB—A kind of wall of stone.
Roches Moutonnées—Rocks rounded by glacial action so that at a distance they look like sheep.
Rock—A mass of earthy or stony matter composed of one or more simple minerals.

SEAM—A layer of mineral, usually applied to coal.
Secondary—The third of the five periods of stratified rocks.
Secular Movements — Those prolonged through many centuries or ages.
Sedimentary Rocks—Those produced by the solidification of sediments left by water.
Seismic—Relating to earthquakes.
Siliceous Rocks—Flinty rocks.
Sill—A layer of volcanic rock.
Silurian—The second Primary system.
Soil—The detritus covering the earth's surface and capable of supporting vegetable life.
Spicule—A needle-shaped body.
Strata—Layers of rock, usually more or less horizontal.
Stratified Rock—Rock arranged in definite layers.
Striation—Scratching of stones due to glacial action.
Strike—The direction of the outcrop of strata.
Subsidence—The gradual sinking of the land.
Subsoil—Consisting generally of earth and stones, intermediate between the soil and the solid rock.
Syncline—An arrangement of tilted strata in troughs.

TERTIARY — The fourth period of stratified rocks.
Throw—The vertical displacement of strata by a dislocation or fault.
Till—Boulder clay.
Triassic — The oldest Secondary system.
Tuff—Volcanic débris, often hardened into rock.

UNCONFORMITY—The disposition of a set of strata upon older ones which lie at a different angle.
Uniformitarianism — The doctrine that similar causes have been at work throughout geological history to produce the same results.
Upheaval—The slow rising of the land.

VENT—The communication between a crater and the subterranean reservoir of molten lava.
Vitreous—Glassy rocks or minerals.
Volcano—A mountain produced by the ejection of lava from the interior of the earth.
Volcanic Rocks—Igneous rocks which have solidified on the earth's surface.

WEATHERING—The modification of rocks by atmospheric or meteorological agencies.

MECHANICAL ENGINEERING

FOUNDRY WORK

ACID STEEL—Steel made from non-phosphoric ores.

Air Belt—The belt encircling a cupola, through which the blast is conveyed to the tuyeres.

Air Furnace—A furnace which utilises the natural draught of a chimney.

Alloy—A mixture of two or more metals, effected by fusion.

Aluminium—Used in numerous alloys. It exercises a cleansing effect.

Anchor—A moulder's chaplet.

Angle Board—Used by pattern-makers for planing angles, hollows, or fillets in.

Angles—Strips of triangular section used for fitting in corners in patterns, and for strengthening castings.

Annealing Oven—Used for the decarbonisation of malleable iron castings.

Apple Tree—Used for cogs of mortice wheels.

Arc Pitch—The pitch of gear wheels measured round an arc of the pitch line.

BABBITT METAL—A white metal used for lining bearings.

Back Plate—A cast-iron plate bolted to the back of a foundry box, for vertical casting.

Bare—Slightly under exact size.

Barrow Ladle, or Sulky—A foundry ladle mounted on a barrow framing.

Bars—The stays, or cross-pieces of moulding boxes.

Basic Steel—Steel made from phosphoric ores, in a converter or furnace having a basic lining (lime).

Bastard Wheel—A wheel which, bearing with another, is not of correct pitch or bevel.

Bead Sleekers—Moulder's tools for smoothing the impressions of beads.

Bed Charge—The bottom charge of coke in a cupola furnace.

Bedding-in—Moulding patterns in the same position in which they have to be cast, without a bottom box.

Beeswax—Used for coating iron patterns to prevent them from rusting.

Bellows—Employed for blowing particles of loose sand, dust, and blackening out of moulds.

Bench—Used by pattern-makers, moulders in small work, and by core-makers.

Bench Rammer—A small rammer used for moulding at the bench.

Bench Work—Work done at the bench, to distinguish it from that done on the floor.

Bevel Wheels—Toothed gears, the pitch planes of which form conic frustra.

Blackening—Charcoal dust, or plumbago, used for dusting foundry-moulds to prevent sand burning.

Blacking Bag—A muslin bag from which blackening is dusted over the surfaces of moulds.

Blacking Mill—A rotating cylinder containing rollers, or balls, which crush charcoal into dust.

Blackleading—Sometimes patterns are treated thus to facilitate their delivery.

Black Sand—The old sand of the foundry floor.

Black Wash, or Wet Blacking—A mixture of charcoal or plumbago with clay water, washed over the surfaces of moulds.

Blast—Air supplied under pressure to melting furnaces.

Blast Furnace—A furnace ranging from 80 ft. to over 100 ft. high, in which iron is reduced from its ores.

Blow—The period during which blast is being brought into a melting furnace, or the act of bringing it in.

Blower—A rotary machine in which an artificial current of air is produced by positive pressure.

Blow Holes—Holes in castings caused by the entanglement of gases in the mould at the time of pouring.

Body Core—A main core.

Body Flange—A pipe flange fitted on the body of a pattern.

Bosh—A tank of water for foundry use.

Boshes—The melting zone of a blast furnace.

Boss—A circular bearing pierced with a hole for a shaft or pin.

Bottom Board—A flat board on which a bottom box is rammed over a pattern.

Bot Stick—The iron rod which holds a stopper of clay at one end for closing the mouth of the cupola, and has at the other a point for tapping.

Box Filling—The black sand of the floor as distinguished from facing sand.

Boxing-up—Making a large pattern to enclose hollow spaces, instead of using solid timber.

Brass—An alloy of copper, tin, and zinc variously proportioned.

Brass Melting Furnace—Generally an air furnace receiving crucibles. Sometimes a reverberatory furnace for large masses.

Brass Moulding—The moulding for brass castings, which differs in some particulars from iron moulding.

Bricking-up—The building-up of the skeletons of loam moulds with bricks.

Bricks—Common bricks, fire bricks, or loam bricks, used in loam moulding and in lining furnaces.

Bronze—A mixture of copper and tin variously proportioned, or with aluminium or phosphorus.

Building-up—Constructing patterns with segmental pieces to ensure permanence of form.

Burning-on—Casting new metal on old for the purpose of repairs.

Burnt Iron—Cast iron which has become largely reduced to the condition of an oxide, and rotten.

Burnt Sand—Sand which has been subjected to intense heat, so that it has no coherence. It is used for parting joints.

CAMBER—Curving of castings and of their patterns.

Carbon—The most essential controlling element in cast iron.

Carbon Cores—Hard, strong cores made of conpressed carbon.

Carriage Ladle—A ladle mounted on a carriage.

Casting—The pouring or founding of the metal.

Casting Upright—Pouring a mould vertically with a view to secure soundness.

Cast Iron—An alloy of iron with carbon and other elements.

Cast Steel—Steel which has been melted and poured.

Centre Plates—Plates used for turning jointed patterns on, the plates being attached at the ends.

Centre Square—An instrument for finding the centre of a body without compasses.

Chalk—Used for whitening pattern-shop drawing-boards, and other purposes.

Chalk Line—A fine line chalked and strained tight, and snapped on a board to leave a straight chalk-mark for sawing by.

Chambered Core—A core enlarged about its central portion.

Changing Hook—A foundry crane hook with two bends for changing ladles of metal from one crane to another adjacent.

Chaplet—A metallic stud, or nail, or piece of hoop iron which affords support to a core independently of prints.

Chaplet Block—A block of wood which sometimes supports a chaplet nail.

Charcoal—Charcoal, when ground, is used for facing moulds.

Charge—The quantity of ore, fuel, and flux which is introduced into a cupola or blast furnace at one time.

Charging Door—The opening of a blast or reverberatory furnace through which the charges are introduced.

Check, or Register—The annular jointing between the top and bottom of loam moulds.

Chilling—Casting against cold iron.

Chord Pitch—The shortest distance between the adjacent centres of the teeth of wheels.

Chucking—Attaching work to lathe chucks.

Cinder Bed, or Coke Bed—A bed laid with cinders or coke at the bottom of a mould, into which the vents collect, and from which they are discharged.

Clay Plug—A plug of clay that closes an ingate until the basin is nearly filled.

Clay Wash—Clay diluted with water, and used for swabbing the bars of moulding boxes and lifters.

Clean Lift—A pattern delivery which does not damage the mould.

Clean Metal—Metal free from sponginess, scabs, and blow-holes.

Clearance—The space between adjacent gear-wheel teeth.

Coal Dust—Ground coal, to be mixed with sand for facings.

Coal Mill—A mill in which coal is ground into dust.

Coat—An application of loam, clay wash or wet blacking to a mould.

Cod—A mass of sand carried on a drawback, or other plate.

Cogs—The wooden teeth of mortice wheels.

Cog Wheel—A wheel with teeth of wood.

Coke—Used in cupolas and blast furnaces, and when ground, for mixing with facing sand.

Coke Baskets—Moulders' hand baskets.

Coke Bed—See *cinder bed*

Coke Mill—Same as *coal mill*

Cold Blast Iron—Iron smelted by cold blast.

Cold Shots—Small globules of cold iron enclosed in castings.

Cold Shuts—Lines of imperfect union in castings.

Collapsible Core Bar—A core bar which is made to fall inwards for ready removal, after the mould is poured.

Combined Carbon—Carbon in a condition of chemical combination with iron.

Contraction—The shrinkage of metal from the liquid state.

Contraction Rule—A rule longer than the common rule by the amount of contraction of iron, or brass.

Converter—The vessel in which Bessemer steel is made.

Cope—The top part of a loam mould.

Core—A central or internal body of sand.

Core Bar—A hollow bar on which cylindrical cores are swept up.

Core Board—A board cut to the profile of a core which is swept up against it.

Core Box—A framing within which a core is rammed.

Core Carriage—A carriage on which heavy cores are run into the stove.

Coring Up—Placing the cores in a mould.

Core Irons—Iron rods rammed in a core to afford a stiffening skeleton.

Core Oven, or Core Stove—An oven or stove in which cores are placed to be dried by heat.

Core Plate—A plate on which cores are swept up.
Core Print—A projection piece on a pattern, into the impression made by which a core is placed.
Core Ropes—Ropes or strings rammed in curved portions of a core, and withdrawn to leave vent holes.
Core Sands—Mixtures of strong sand.
Core Trestles—Trestles on which core boards and core bars are supported.
Crane—Used for lifting and turning over moulds and castings.
Crane Ladle—A heavy ladle which is slung and carried by a crane.
Cross—A double beam of the form of a St. Andrew's cross, suspended from a crane, and carrying suspension loops for moulders' work.
Crucible—Used in melting steel and copper alloys.
Crucible Cast Steel—Steel melted in a crucible.
Cupola—The furnace in which cast iron is remelted.
Cupola Hoist—A light hoist for lifting iron, coke, and limestone to the cupola platform.
Curving of Patterns—Patterns are curved in the opposite direction to that taken by their castings in cooling.

DAUBING—Lining a furnace or ladle with fire-clay.
Dead Head—A head of metal on a casting.
Dead Melting—Thorough melting.
Delivery—The withdrawal of a pattern from its mould.
Devil—An open cage in which a coke fire is lit for drying moulds.
Dog—A staple, or iron cramp.
Double Shrinkage—Two shrinkages must be allowed for when making patterns from which to cast patterns of metal.
Dowels—Pins uniting loose pieces temporarily.
Drag—The bottom box in moulding.
Draught—The taper of a pattern.
Draw—The same as *delivery*.
Drawback—A mass of sand carried on a plate, without a print.
Drawing Board—A board on which shop drawings are made to actual sizes.
Drop Bottom Cupola—A cupola in which the bottom is dropped to discharge the ashes.
Drop Print—A pocket print.
Dry Brush—A soft brush used for removing dust from moulds.
Drying—Driving off the moisture from moulds and cores by heat.
Drying Stove—A stove in which moulds and cores are dried.
Dry Sand—Strong sand, dried in the stove.
Dull Metal—Metal imperfectly melted.

EMERY WHEELS—Used for fettling castings.

FACE PLATE—A plate on which pattern work is turned.
Facing—A portion standing above the main surface of a pattern or casting.
Facing Sand—The sand which lies next a pattern.
False Core—The false core of a brass moulder corresponds generally with the drawback of the iron moulder.
Fan—A rotary machine for supplying blast to a cupola.
Feeder—A body of liquid metal which supplies shrinkage loss.
Feeding—Assisting the ingress of metal to the mould by the movement of a rod up and down in the runner.
Feeding Rod—A rod of ¼ in. or more in diameter, used for feeding.
Fettling—Removing runners, fins, and other excrescences from castings.
Fillet—An angle, or hollow.
Fin—A thin expansion of metal spreading out from mould joint.
Flask—A moulding box.
Flat Rammer—A rammer having a flat end, used for finishing.
Floor Work—Moulding done by kneeling or bending over moulds on the floor.
Flow-off Gate—A riser gate.
Fluid Metal—Metal thoroughly melted.
Flux—Lime, which unites with earthy matter, etc., present in iron ore, forming slag.
Foundry—The building in which casting is done.
Foundry Crane—A triangular framed crane, having its top member horizontal.
Foundry Pig—Grey pig, fluid when melted.
Full—Slightly oversize.
Furnace Linings—Bricks of fire clay and ganister.

GAGGERS—Prods cast on loam plates.
Ganister—Silicious sand, and fire clay used in furnace linings and steel moulds.
Gas Coke—By-product of gas works, sometimes used in brass furnaces.
Gates—Ingates, or runners, through which metal enters a mould.
Grain—The texture of metal, or of wood.
Graphitic Carbon—Free carbon, present in grey cast iron.
Green Sand—Sand which is not dried.
Green Sand Moulding—Work done in green sand.
Grey Iron—An open grained iron, only moderately strong.
Grid—An iron frame on which a core or drawback is built.
Guide Iron—An iron curved to control the movements of a strickle.
Gun Metal—An alloy of copper and tin.
Gutters—Narrow channels cut in the joint faces of moulds for the escape of gas.

HALF PATTERN—One of the halves of a jointed and dowelled pattern.
Halving—A form of flat joint uniting pattern parts.
Handing—Making pattern parts right and left.
Hand Ladle—A small ladle carried by a single shank.
Hard Coke—Furnace coke, used in cupolas.
Hard Iron—Iron which is either highly silicious or chilled.
Hard Ramming—Ramming a mould hard, to prevent risk of lumps.
Hatching—Cutting up the surface of moulds with the trowel to assist the adherence of fresh sand for mending up.
Hay Bands—Used to bind the loam in swept-up cores.
Head Metal—A supplementary mass of metal on top of a casting, to secure soundness in the latter.
Hemp—Used instead of hay bands in small cores.
Hollows—Concave portions inserted in angles of patterns to ensure strength in the castings.
Honeycombing—A state of general sponginess in a casting.
Horse Manure—Used as a binding and venting material in strong sand.
Hot Blast — Employed generally instead of cold blast for smelting iron.
Hot Metal—Metal thoroughly melted.
Hot Sand—Sand from which recently poured castings have been removed.

INGOT—A mass of metal of rectangular section which has to be remelted for castings.
Iron—Foundry iron owes its virtue to the presence of carbon and other elements.
Iron Cement—A mixture used for joints and filling blow holes.

JAGGERS—The same as *gaggers*.
Joint—The parting of a pattern or of a mould.
Joint Board—A board on which a pattern is rammed.

LADLE—The vessel which receives molten iron from the cupola, and from which it is poured into moulds.
Lagging—Building up patterns with narrow strips of wood.
Lead—Used for lining up portions of patterns.
Leather—Used for the same purpose as lead, and for hollows.
Levelling—Necessary when work is moulded by bedding in the floor.
Lift—The act of withdrawing a pattern from the mould; or the character of the draw.
Liftering—Hanging and setting lifters in the sand of moulds.
Lifters—Hooks hung from the bars of boxes to assist in supporting the sand.
Lifting Plate—A plate attached to a pattern to receive lifting screws.
Lifting Screw—A screw with an eye used in withdrawing a pattern from the mould.
Lifting Strap—A piece of hoop iron attached to deep patterns for withdrawing them by.
Lime—A flux mixed with the charges of iron and coke in the cupola.
Lime Bag—A muslin bag from which lime is dusted over the joints of moulds, to show contact.
Loading—Weighting box parts previously to pouring.
Loam—A mixture of strong sands, rendered plastic with water.
Loam Board—A board by which a loam mould is swept up.
Loam Bricks—Bricks made of loam and dried.
Loam Cake—Pieces of dried loam.
Loam Mould—A mould made in loam.
Loam Pattern—A pattern made in loam instead of in wood.
Loam Plate—A plate on which a loam mould is built.
Loosening—Rapping a pattern.
Loose Pieces—Pieces which are not fastened permanently on a pattern body, but have to be left behind in the mould.
Lug—A projecting portion.

MACHINE MOULDED WHEELS—Toothed wheels made from sectional patterns in a machine.
Machine Moulding—Moulds in which some portions of the work are done by machine.
Malleable Cast Iron—Castings which are rendered malleable by decarbonisation or annealing.
Mending-up—Making damaged portions of moulds good.
Mending-up Piece—A piece used in mending-up, as a guide for finishing the sand outlines by.
Metal Patterns—Used when large numbers of similar pieces have to be cast.
Middle Part—The central portion of a moulding box having three or more parts.
Model—Sometimes applied to denote a pattern.
Mortice Wheel—A cog wheel, or one fitted with wooden cogs.
Mould—The structure into which metal is poured.
Moulding Box—The framework in which sand is rammed for moulds.
Moulding Machines—Machines used for producing moulds.
Moulding Tub—Used by brass founders as a receptacle for sand, and over which they work.

NAILING, NAILS—Embedded in weak portions of sand as supports.

OLD SAND—Sand which has been used continuously, and become weak.

Open Joints—Boards jointed side by side, but not in actual contact.
Open Sand Work—Moulds without a covering.
Oven Coke—Hard coke.

PAINTING—Denotes the application of wet blacking to moulds.
Paper Joint—In segmental and some other work, temporarily glued joints are made by the insertion of paper.
Parallel Print—Prints are parallel when they mould sideways.
Parallel Strips—Winding strips used for levelling mould faces and planing timber by.
Paring Tools—Long thin chisels and gouges.
Parting—The separation of the parts of a mould.
Parting Sand—Burnt sand used to prevent mould joints from sticking.
Pattern—A model from which an impression is taken in sand.
Pattern Register—A list of patterns kept in a book.
Pattern Stores—The building in which patterns are stored.
Peasemeal—A cementing material between the face of a mould and the blackening.
Peg and Cup Dowells—Brass dowells driven into the joints of patterns.
Pegging Rammer—A small rammer for small moulds and intricate portions.
Phosphor Bronze—Bronze to which a little phosphorus is added.
Phosphorus—An element which renders steel and cast iron brittle. A small quantity increases the fluidity of iron.
Picker—A pointed wire used for pulling small patterns from the mould.
Pickling—Removing the hard outer skin from castings by immersion in dilute sulphuric or nitric acid.
Pig Iron—The form in which iron is cast and sold for foundry use.
Pig-Iron Breaker—An appliance or a machine for breaking pig into short lengths for remelting.
Pine—Used more than any other material for foundry patterns.
Pipe Nails—Chaplet nails, used for supporting the cores of pipes.
Pitch—The distance between the centres of contiguous teeth in cog wheels.
Pitch Circle—The circle on which the pitch is struck.
Pitch Diameter—The diameter of a pitch circle.
Pit—A hole in which deep moulds are placed for casting.
Plaster of Paris—Used in making temporary patterns, and core boxes.
Plate Moulding—Moulding off patterns attached to jointing plates.
Platen—The table of a moulding machine.
Plumbago—Used for dusting moulds.
Pocket Print—A print which is continued above the position to be occupied by the core.
Pot Metal—A very common and cheap brass.
Pouring Basin—The depression into which metal is poured first before it enters the runners.
Print—A projection which makes an impression as a guide for the insertion of a core.
Prods—Jaggers or gaggers.
Pulling-up—The tearing-up and fracture of the sand in a mould.

QUICK—Denotes a curve of small radius.

RAMMER—A tool for consolidating sand round patterns.
Rapping—Loosening a pattern preparatory to its withdrawal.
Rapping Bar—A pointed iron bar used for rapping.
Rapping Hole—The hole in which a rapping bar is inserted.
Rapping Mallet—A wooden mallet used for rapping a pattern during its withdrawal.
Rapping Plate—A metal plate attached to a pattern to receive a rapping bar.
Receiver—A vessel which collects molten metal for pouring.
Reduction—The extraction of metals from their ores by heat and chemical affinities.
Remelting—Iron, and copper alloys are remelted to render them homogeneous and stronger.
Reverberatory Furnace—An arched furnace, with natural draught, used in some foundries.
Reverse Mould—A dummy mould of plaster upon which actual moulds are rammed.
Riddle—A coarse sieve.
Riser—An overflow exit from a mould.
Rodding—Laying rods in the sand of moulds to sustain it.
Rolling over—The same as *turning over*.
Rough Coat—A first coat of loam.
Rumble—A tumbling barrel.
Rumbling—Tumbling, or fettling in a rumble.
Runner—The channel through which metal enters a mould.
Runner Pin—A pattern for forming a runner.

SAFETY LADLE—A ladle tipped by means of toothed gears.
Saggers—The packing boxes used for annealing malleable cast iron work.
Sand—The matrix of foundry moulds.
Sand Bin—A receptacle for sand.
Sand Burning—Results from pouring hot iron against sand not protected with blackening.
Sand Joint—A moulder's joint.
Sand Mixer—A machine for mixing sands.
Sand Sifter—A machine for sifting sand.
Scab—An excrescence on a casting.
Scrap—Old metal.
Scrap Heap—A receptacle for scrap.
Scull—The scaly lining left in a ladle or furnace after use.
Segmental Work—Built-up pattern work.
Self Delivery—The delivery of a pattern having hollow portions instead of by coring.
Shank Ladle—A ladle having a handle or handles, to distinguish it from a *crane ladle*.
Shellac Varnish—The varnish used for the protection of patterns.
S Hooks—Lifters.
Shrinkage—Used in the same sense as *contraction*.
Sieve—Used for sifting sand.
Skewers—Used for holding pieces loosely to patterns.
Skimmer—A flat bar employed for baying back dirt fron the surface of metal being poured.
Skimming Chamber—A chamber in the course of a runner, designed to separate the dross, and prevent its entry to the mould.
Skin—The surface of a casting.
Skin Drying—Drying the surface only of a green sand mould.
Slag—A glassy substance produced by the union of earthy matters with calcium.
Slagging—Tapping out the slag.
Sleeking—Smoothing the surface of a mould with tools.
Slicking—The same as sleeking.
Slings—The loops which sustain moulding boxes from the cross
Soft Metal—Grey iron.
Soft Ramming—Easy ramming, which often produces lumps.
Splitting—Casting pulleys and wheels in halves.
Sponginess—Openness of texture in castings.
Spray—A series of runners arranged parallel or star-shaped.
Sprigging—Nailing.
Spring Chaplet—A chaplet formed by a loop of hoop iron.
Stakes—Bars or rods driven into the floor as guides to a top box.
Stays—Bars of moulding boxes.
Steady—An appliance used for encircling patterns of columns and pipes during turning to ensure steady running.
Stopping-off—Producing a shape in the mould different from that of the pattern.
Stopping-over—Filling up pocket prints.
Strickle—A profiled piece by which sand is scraped to any desired form.
Striking Bar—The bar to which a loam board is bolted.
Striking Board—The board by which loam, or green sand, is swept up.
Stripping Plate—A plate through which a pattern is drawn in delivery.
Strong Iron—Mottled iron, in which carbon is largely in a combined state.
Strong Sand—Sand containing loam and horse manure.
Sullage—The scoriæ of metal.
Sulky—A barrow ladle.
Sulphur—A very minute proportion of this element injures cast iron, rendering it white, and is objectionable in foundry coke.
Swab—A brush used for the laying-on of clay wash, or of wet blacking.
Swab Pot—The pot which contains clay water, or wet blacking.
Sweep—A curved piece.

TACKLE—Lifting and hauling appliances.
Taper—The thinning or narrowing of patterns from above downwards.
Tap Hole—The hole from which molten metal is drawn.
Teeming—Pouring steel into moulds.
Thickness—A body of loam which represents thickness of metal.
Three-Part Box—A moulding box, comprising top, bottom, and middle.
Tile—The cover of a brass furnace.
Tinned Nails—Chaplet nails tinned to prevent rusting.
Tumbling Barrel, or Rumble—A revolving drum, in which castings are fettled.
Turning-over—Ramming the first part of a mould in the opposite position to which it has to be cast.
Turn-over Board—A board for ramming the bottom part of a mould on.
Tuyeres—The openings through which blast is directed into a blast furnace or a cupola.

VARNISH—Used for protection of patterns.
Venting—The formation of passages in moulds for the escape of gas.
Vent Wire—A rod by which vents are produced.

WASTER—A spoiled casting.
Water Bosh—A tank of water for foundry service.
Water Brush—A soft brush used for moistening the edges of moulds with water.
Weak Sand—Sand with little cohesion.
Wet Blacking—Plumbago in solution in water.
Wet Brush—A soft brush used for laying-on wet blacking.
White Iron—Iron which contains all its carbon in the combined state.
Winding Strips—Parallel strips.

YELLOW METAL—A soft variety of brass.

ZONES—The melting areas in cupolas.

ACCUMULATOR—A vessel in which water is stored under pressure for the operation of hydraulic presses.

Adamson Flanged Seam—A joint in the furnace flues of many horizontal boilers, formed by flanging the ends of the flue lengths, and riveting them together through an intermediary caulking ring.

Air Furnace—A reverberatory furnace, using the natural draught of a chimney.

Angle Bevelling Machine—A machine fitted with rolls for imparting various angles to the webs of angle sections.

Angle Iron, Angles—Rolled sections of iron and steel having two webs at right or other angles with each other.

Angle-iron Furnace—A reverberatory furnace used for heating angles.

Angle-iron Shears—Shears of V-shape, used for cutting off angles.

Angle-iron Smith—A workman whose duties are confined to the preparation of work done at the forge.

Annealing—The heating and slow cooling of iron and steel after work has been done, in order to restore ductility and homogenity.

Annealing Furnace—A reverberatory furnace used for the purpose of annealing.

Anvil—The block upon which forgings are treated. The best are of wrought-iron, welded up, and steel-faced. Many cheap anvils are produced by casting.

BANKING UP—Making up a forge fire with green coal or small coal, damped with water.

Bars—The round, or rectangular sections in which iron and steel are rolled. They are *rounds*, *squares*, and *flats*.

Beading—The burring over and rounding of the ends of boiler tubes.

Beading Tool—A drift-like tool used for beading boiler tubes.

Beak Iron, or Bick Iron—The conical projection of an anvil.

Bending Blocks—Blocks of cast iron variously shaped to serve for bending bars, sections, and plates by.

Bending Rolls—Machine rolls used for bending large plates in. The rolls have their axes either horizontal or vertical.

Bessemer Steel—Used in tyres, rails, and for many forgings.

Bevelled Iron—Flats having one or two edges bevelled.

Blazing Off—The burning of an oil or fat having a known flash-point, which corresponds with a temperature suitable for tempering springs and some other articles.

Bleeding—The presence of red rust on the plates of boilers, which indicates corrosion within the plates.

Blisters—A defect in plates due to the entanglement of slag or scale in the bloom previous to rolling.

Blue Heat—Corresponds with a stage between a low red and a black heat, at which, if severe work is done on steel and iron, serious loss of ductility and strength results.

Boiler—The vessel in which steam is generated by the action of heat.

Boiler Fittings—Sundry parts which have to be attached to a boiler; as doors, seatings, bridge, fire-box, &c.

Boiler Flues—The furnaces, or the brickwork, or smoke flues.

Boiler Flue Flange Drilling Machines—Machines for drilling the rivet holes in the flanges of Adamson seams.

Boiler Prover—A force-pump, with gauge, used for testing boilers by water pressure.

Boiler Scaling—Chipping the hard deposits from the interiors of boilers with a scaling hammer.

Boiler Shell—The outer body, as distinct from the furnace.

Boiler Shell Drilling Machines—Machines for drilling the rivet holes in shell plates, generally after the plates are all fitted in series.

Boiler Shop—The shop in which boilers are made. Its equipment consists chiefly of heavy machinery and forges.

Boiler Smithy—The department in which the forged work is done by the angle iron smiths.

Boiler Stays—Rods or tubes used for reinforcing the flat surfaces of steam boilers.

Boiler Tubes—Fire tubes in the locomotive type; water tubes in the water-tube type.

Bolster—A ring upon which holes are punched, and through which the burr is pushed.

Bolt Machine—A forging machine in which bolts are formed by rapid reduction in concave dies.

Borax—Used as a flux in welding steel and iron.

Bosh—The water tank in which the smith cools and quenches work.

Bossing—Forming bosses on forgings.

Bowling Hoop—An expansion ring of arched section used in furnace tubes.

Box Girder—A girder having four sides enclosing a hollow rectangle.

Bracings—Arrangements of bars in plated work which change the direction of stresses, so reinforcing otherwise weak members.

Brands—Trade marks used to denote qualities of iron and steel, and the houses from which they are sent.

Brick Arch—The arch in a locomotive fire-box which deflects the gases backward before they pass into the fire tubes.

Bricked-up Fire—A hollow fire enclosed with bricks, in which rolled sections are heated for welding, and by which they are prevented from contact with the fuel.

Bridge—The barrier placed at the back of the fire-grate in a horizontal boiler to promote combustion.

Buckle—A state of unequal tension in plates.

Bulb Sections—Bars, angles, and tees, having one edge thickened or beaded.

Bulldozer—A machine which presses work into dies by means of a reciprocating ram.

Burnt Iron and Steel—Metal which has been overheated at the forge, and injured thereby.

Burr—The piece removed by a punch.

Butt Joints—Joints that abut by their edges, and then are covered by and riveted through butt straps.

Butt Welding—The welding of joints brought into simple opposition.

CASE HARDENING—Imparting surface hardness to iron and steel by prolonged contact with bones, leather, charcoal, or ferro-prussiate of potash, at a red heat.

Caulking—Burring up the edges of riveted plates with a caulking tool to render the seams watertight.

Caulking Ring, or Strip—Wrought-iron or steel inserted in a joint to provide for caulking against.

Channels—Rolled sections the sectional form of which is that of three sides of a rectangle.

Chipping Chisel—A tool used for cutting iron and steel while cold.

Chisels—Used under the name of cold and hot setts.

Chisel Rod—Rod from which cold chisels are made, being of the same section as the chisels.

Clamps—Used for holding pieces of work temporarily.

Closing—Turning over the tail of a rivet, or the jointing of a weld.

Cold Chisel—A *chipping chisel.*

Cold Saw—A circular saw used for cutting off bars and rolled sections without heating them.

Cold-short—Signifies a condition in wrought-iron and steel in which it cannot be worked below a dull-red heat without risk of fracture.

Cold Tests—The testing of specimens of iron and steel while cold by bending and drifting them.

Collapsing Pressure—The pressure to which boiler furnaces are subjected, tending to force them inwards and crumple them.

Conical Mandrel—An appliance, circular in plan, and a conic frustum in elevation, around which rings of different sizes are bent and corrected.

Conical Tubes—The Galloway tubes used in the furnaces of many steam boilers.

DABBING ON—Making a weld by the simple contact of flat faces.

Die-Forging—Making forgings by stamping them into matrices or dies of hard metal.

Dolly—An appliance held up under a rivet head while the tail is being closed.

Drawing Down—The act of reducing portions of forgings by hammer blows.

Drift—A tapered tool used for enlarging holes.

Drilled Holes—These are used in preference to punched holes in high-class work.

Drop Forging—The practice of *die forging* when done under drop hammers.

Ductility—The capacity of metals of being extended considerably before fracture occurs.

ELASTIC LIMIT—The limit beyond which a body will not return to its original length on removal of stress.

Elongation—The amount of extension of a body under stress, generally reckoned at the point of fracture.

Envelopes—The forms of the plates required to enclose a body of any shape or dimensions.

Expanding—Specifically, enlarging the ends of fire tubes to make them steam tight.

Extras—Charges above the usual rates, made when the dimensions or shapes of plates, bars, or sections, involve increased expense in manufacture.

FAGGOT, or FAGGOTED SCRAP—Separate odds and ends of wrought-iron brought to a welding heat and consolidated by hammering.

Faggoting, or Piling—Preparing *faggoted scrap.*

Ferrules—Rings inserted in the ends of many fire tubes to protect the ends of the tubes from the action of the fire.

Fibre—The structure of wrought-iron which is developed during rolling.

Fire-box—The furnace of a locomotive or a vertical boiler.

Flanging—Producing flanges by bending over the edges of plates.

Flats—Bars, the section of which is rectangular but not square.

Flatters—A species of hammer struck by a sledge and used to impart a neat finish to plain surfaces.

Flux—Powdered sand and borax are fluxes used by smiths when making welds.
Forge—An open fire carried on a low platform, and surmounted by a hood and chimney.
Forge Tests—Rough bending and drifting tests made on specimens at the forge.
Forging—The practice of producing shapes in malleable metal at the anvil.
Fullers—Tools having convex edges, struck by a sledge and used for drawing down.
Fullering—The process of drawing down by a fuller. Also broad finishing following caulking.

GALLOWAY BOILER—A modification of the Lancashire type, having the two flues united in one at the rear, and fitted with Galloway tubes.
Galloway Tubes—Cross water-tubes of conical form.
Gap Gauge—A plate gauge having its edges notched to standard widths for measuring work during forging.
Gaseous Fuel—Used for heating reverberatory and rivet furnaces.
Girder—A beam which occurs in numerous designs.
Girder Stays—The bridge stays that reinforce the top of a locomotive fire-box.
Glut—A strip of square or triangular section used for welds.
Glut Weld—A weld made with a glut strip. It is both a butt and a V-weld.
Gusset Stay—A diagonal boiler-stay made of plate and angle.

HAMMER—A percussive type of tool which includes hand, holding-up, set, and sledge groups.
Hammerman—A smith's striker who wields the sledge.
Hammer Shaft—The handle of a sledge.
Hardening—The result of heating steel and quenching it in liquid suddenly.
Heat—Making a mass of metal hot for the purpose of forging is termed *taking a heat.*
Heater—A white-hot lump of metal placed in contact with plated work at a locality where slight correction is required.
H-Irons—*Joist sections.*
Holding-up Hammer—A hammer held under a rivet head while the tail is being closed.
Hollow Fire—A smith's fire banked round to enclose a hollow space clear of fuel.
Hollow Tools—*Swages.*
Hot Saw—A circular saw which cuts red-hot metal.
Hot Sett—A smith's chisel ground with a keen edge to sever hot metal.
Hydraulic Flanging, and Forging—Flanging and forging done on dies actuated by hydraulic presses.
Hydraulic Test—A pressure test for steam boilers.
INTERNALLY FIRED BOILER—A steam boiler having its furnaces enclosed within the shell.
Iron—Used in the form of bars, plates, and rolled sections.

JOIST SECTIONS—Rolled sections in iron and steel of the form of the letter H.
Jumping-up—*Upsetting.*
Jump Weld—A *butt weld.*

LAMINATION—A condition of iron plates the layers of which are imperfectly united.
Lap Riveting—The union of overlapping edges by rivets.
Lap Weld—A weld joint made by the overlapping of edges.
Letting down—Lowering the temperature of steel from the hardening to the tempering heat.
Levelling Block—An iron block or table on which plates are levelled by hammer blows.
Limiting Dimensions—The maximum dimensions in which bars, plates, and rolled sections are manufactured.

MALLEABLE IRON—Wrought iron.
Mandrel—A bar of round or other section around which an eye or ring is bent or corrected.
Mates—The men who work together, as the smith and his striker.
Monkey—A kind of heavy hammer suspended and swung by a rope.
Multiple Machines—Machines which embody provision for punching or for drilling a number of holes simultaneously.

OLIVER—An old-fashioned hammer operated by a treadle and spring pole.
Overall—An aggregate dimension, the sum of a number of smaller ones in series.

PAN HEAD RIVET—One the head of which has the section of a conic frustum.
Pendulum Hammer—A monkey.
Piling—Fagotting.
Planed Edges—These are adopted on high-class work to ensure smooth edges and good fitting.
Plate Furnace—A reverberatory furnace.
Plate Gauge—A notched gauge for measuring the thicknesses of plates.
Plates—Rolled material in which the length and width greatly exceed the thickness.
Plating—The working up of plates into girders and boilers.
Porter Bar—An extension on a forging, held in the hands of the smith.
Punch—A tool used for driving a hole through a forging.

QUENCHING—Thrusting heated steel into water or oil to effect hardening or tempering.

RED HEAT—Denotes the colour as seen in a dull light, as the shadow of a forge or wall.
Red-shortness—A condition in which iron and steel cannot be worked at a red heat without fracturing.
Reduction of Area—The diminution in cross section which takes place at the point of fracture of a bar subjected to tensile stress.
Reverberatory Furnace—An arched furnace in which work is heated by incandescent gases apart from contact with the fuel.
Rivet—A means of union between two or more pieces, effected by enlargements at both ends of a parallel shank, or pin inserted through a hole.
Rods—Bars of iron or steel of various small sections.
Rolls—Machines used either for bending plates to curves or for flattening them in true planes.
Rounds—Bars of circular cross section.

SAND—Used as a flux in welding wrought-iron.
Sawing—Rolled sections are sawn to lengths with economy of material and time, and the advantage of leaving smooth ends.
Scale—The incrustation that forms in steam boilers.
Scaling—Chipping off boiler scale with a chisel-like scaling hammer.
Scarf Weld—A lap weld in which the edges in contact are sloped or tapered.
Seam—A lap joint, or a flanged seam in a furnace.
Seating—An intermediate fitting on a boiler shell to receive a fitting or mounting.
Sections—Non-plane forms in which iron and steel are rolled.
Setts—Smith's chisels.
Sett Hammer—A broad hammer which is struck by a sledge.
Shearing—Cutting off iron or steel with a scissor-like action.
Sheets—Manufactured materials of large area, but thinner than plates, or below ¼ in. in thickness.
Ship Plates—The commoner kinds of manufactured steel plates.
Shrinkage—Allowance for shrinkage of forgings has to be made in smith's dies.
Sketch Plates—Plates cut to special shapes at the steel works and for which extra prices are charged.
Sledge—A heavy hammer having a long handle to permit of swinging it round in a circle.
Snap—A steel die used for imparting a neat finish to rivet tails.
Snaphead Rivet—One having a head semicircular in section.
Squares—Bars square in cross section.
Stays—Used for stiffening the flat plates of boilers.
Stay Tap—A long tap used for screwing holes in fire-boxes.
Stay Tubes—Smoke tubes which also fulfil the function of stays.
Steam Hammer—Used largely in the heavy work of the smithy.
Steel—Mild steels, or those low in carbon, are used by smiths. They include Open Hearth and Bessemer products. Carbon steels are chiefly used for cutting tools.
Swage Block—A rectangular block containing numerous bottom swages, with holes for bending.
Swages—Tools for imparting shapes to forgings. Called top and bottom tools.
Swaging—Drawing down.

TEES—Rolled sections having the form of the letter T.
Telescopic Plating—Relates to cylindrical boiler-shells the rings of which are conic frustra.
Tempering—Hardening carried to a certain stage only, less than the maximum possible.
Temper Tests—Tests made on hardened materials to ascertain their ductility and strength.
Templet—A strip, plate, or framing used for marking out work from.
Templet Maker—A boilermaker whose duties are restricted to the preparation of templets.
Thinning—Corners of boiler plates are thinned where adjacent plates overlap.
Tongs—Used in various forms at the forge and power hammers.
Tongue Joint—A V-joint made for welding.
Tube Expander—An appliance used for tightening the ends of smoke tubes in their tube plates.
Tubing—Inserting tubes in boilers.
Tuyere—The opening through which blast is delivered to a forge.

UNITED INCHES—The total section in square inches of a rolled angle, channel, joist, or tee.
Upending—Turning a bar into a position with its axis vertically.
Upsetting—Enlarging a portion of a bar by jumping it endwise.

VEE WELD—A weld joint in the shape of the letter V.

WASHING-OUT—Periodical cleaning of boilers with a jet of water.
Welding—Making joints between heated metals and alloys without any cementing materials or extraneous means of union.
Wrought Iron—A comparatively pure iron prepared by puddling.

YORKSHIRE IRON—The purest brands of wrought iron, prepared in Yorkshire

ZEDS—Rolled sections having the shape of the letter Z.

MACHINE & FITTING-SHOP TERMS

THIS DICTIONARY EMBRACES ONLY OPERATIONS CARRIED ON

ADJUSTABLE STRIPS — Metal strips by which compensation for wear of machine slides is effected.

Adjustments—Slight movements and corrections effected during the setting of work in machines, and during its subsequent erection.

Angle Plate—A casting having two faces at right or other angles, and used for the attachment of work on machines.

Angles of Tools—The angles included between the two faces of cutting tools. They range from just below 90° to about 20°.

Angular-hole Drilling — Producing square, triangular, and other pentagonal holes by means of a cutter, which is moved in a path corresponding with the shape in plan of the hole.

Angular Thread—A screw thread, the section of which is an acute angle, as distinguished from a square thread.

Annealing—Softening hard steel to relieve it of internal tension, or to render it easy to machine.

Arbor—A spindle or mandrel for holding cutters or work upon.

Arboring—Facing a boss around a hole, with a cutter termed an *arboring tool* held in a stem,

Arc of Contact—The distance occupied by a pair of gear teeth in mutual contact, the measurement being taken on the pitch line.

Arc Pitch—The pitch of gear teeth measured round the arc of the pitch line.

Automatic—A movement, operation, or arrest of motion, embodied in a moving mechanism without direct intervention of the attendant.

Axial Pitch—The pitch of a single helix in a multiple-threaded screw, measured in the longitudinal axis.

BACKING OFF—Imparting clearance back from the cutting edges of tools and cutters. Applied specifically to milling cutters, reamers, and taps. Also termed *relieving*.

Back Steady—A support for long, slender work being turned in the lathe, or to similar work being ground. It may be a fixed or a travelling steady.

Bare—Signifies that a dimension is very slightly below absolutely correct dimensions.

Bedding — Making a proper fit of an element of mechanism on another, or of a mechanism on its foundation.

Bench—A bench provided with a vice and drawer is used by fitters. It has a timber top carried on supports of iron or wood.

Between Centres—Setting work for turning or grinding between the point centres of the fast and loose headstocks.

Bevel Gears—Toothed gears, the pitch planes of which are conic frustra.

Black Bars—Bars of iron or steel used as they leave the rolls.

Black Holes—Cored or forged holes, as distinguished from those which are drilled.

Black Nuts — Nuts which are not machined or polished.

Black Work—Castings and forgings which are not machined.

Blank — A piece of metal or alloy machined in readiness for subsequent detailed operations in other machines.

Blank Flange—A flange which closes the end of a pipe.

Bob — The weight on the end of a plumb line. A polishing bob.

Bolt — A screwed fastening having a head solid with the shank, and a nut tapped to fit the screwed end.

Bore—A hole. To *machine* a hole is to bore it.

Boring—Usually the enlargement of a hole already existing.

Boring Collar—A cone plate.

Borings—The chips removed by a drill or boring tool.

Boss — A circular piece through which a hole is made. The boss gives the necessary depth or thickness to the hole.

Bossing — Turning the outsides of bosses in a lathe, a drilling, or a boring machine.

Bracket—An angular casting or forging which carries some form of bearing or anchorage.

Brasses—The loose linings of shaft bearings made in that alloy or in gunmetal.

Brass Work—Steam or water fittings made in the copper alloys.

Bright Bars—Bars which are planished or polished, so that they have not to be turned in the lathes and automatics, except where reduction is necessary.

Bright Nuts—Nuts which have been machined and polished.

Bright Work — Work which is machined and polished.

Buff Wheel — A polishing wheel of wood covered with leather or emery-powder. The work is termed *buffing*.

Burnisher—A piece of smooth steel, or a half-round file with the teeth ground out. It is used for polishing filed work by friction, termed *burnishing*.

Bush—The internal lining of a bearing. It is of copper alloy or a white metal, and is fitted by driving in, termed *bushing*.

CAP — The cover of a divided shaft bearing.

Card Wire—A brush made of steel wires used for cleaning the teeth of files.

Carrier—A looped piece of steel which clips an object to be driven between centres. Also termed a *dog*. See *driver*.

Cast Steel—Used for cutting tools in all shops.

Catch Plate—A small face plate which holds a driver. See *driver*.

Centre Line—Dimensions on circular and other bodies are generally taken from centre lines, which are the first dimensions to be laid down.

Centre Pops—Dots marked by a centre punch along the course of dimension lines.

Centre Punch—A pointed tool struck by a hammer to produce shallow conical depressions, or pops, and centres.

Centres — The mathematical point whence circles are described. The term also signifies the conical supports used in lathes and other machines for the support of work, either revolving or fixed.

Centring — Marking the centres on shafts, bars, and other work.

Chalk—Used for whitening the rough surfaces of castings and forgings, to show up the lines and centres scribed by the liner-off.

Chatter—Vibration during machine operations due to insufficient rigidity of the tool, work, or machine.

Checking In—Fitting parts one within the other by a projection and a seating. Also termed *registering*.

Check Nut—A lock nut.

Chipping—Cutting metal with a cold chisel driven with hammer blows.

Chipping Strips — Strips standing slightly above a broad surface, to be levelled by chipping, instead of by cutting over the whole area of the surface.

Chord Pitch — The shortest distance between the centres of adjacent teeth of gear wheels.

Chucking—The attachment of work to lathe chucks or holders.

Chucking Reamer—A reamer with a parallel shank to be held in a self-centring chuck.

Circular Nut—A round nut with holes drilled in it for a tommy. Used on many machine spindles.

Circular Pitch—Equals the division of the circumference of the pitch line of a wheel by the number of its teeth.

Clams—The soft loose jaws of vices.

Clean Cut—A cut surface which is smooth and not striated in any way.

Coarse Feed—A large relative amount of traverse imparted to a cutting tool.

Cold Chisel—A chipping chisel.

Collar—A ring encircling a shaft or spindle.

Cutter—A small loose cutting tool fixed in a bar instead of being provided with a solid shank.

Cutting Angle—The angle included between the two faces of a cutting tool.

DEAD LEVEL—Absolutely level.

Dead Size — Work produced to an exact dimension.

Diametral Pitch—Equals the number of teeth in a wheel to one inch of the pitch diameter.

Dog—A carrier. Jaw of a lathe chuck.

Double-threaded Screw — A screw with two helices half a pitch apart.

Draw Filing—Smoothing a surface by working a file along it nearly at a right angle, and parallel with the work.

Drawing-on — Pulling wheels over their axles.

Drilling Templet—A templet of sheet or cast metal having holes in it as guides for drilling by.

Drip Can — A can containing soapy water which drips on the points of a cutting tool, so lubricating and keeping it cool.

Driven—A wheel or pulley which is actuated by another.

Driver — A wheel or pulley which actuates another, or others. An appliance for rotating lathe work.

Driving Fit—A shaft or bush which fits in such a way that hammer blows are required to drive it into place.

Drum—A wide belt pulley; also a hoisting barrel.

Drunken Screw — A screw thread which has a wavy outline.

EMERY — Used for abrading and polishing, in the form of paper, cloth, powder, and consolidated in the form of wheels.

Erecting—The final putting together of mechanisms, following the preparation of their individual sections in other departments.

Even Pitch—The pitch of a screw being cut in the lathe is even when it has the same number of threads as the lead screw, or some aliquot parts of the same.

Expanding Mandrel — A mandrel capable of slight enlargement to suit bores of different sizes.

External Thread—A screw cut on the outside of a cylinder.

FACING—Turning a plane surface. A definite area standing above the general surface of a casting, or forging.

Fair or Flush—Signifies that surfaces are in one plane.

False Key—A key in the form of a pin driven into a hole drilled half way into a spindle and half way into the bore.

Feed—The amount of traverse of a tool, or work, during cutting

Feed Screw—A screw which imparts feed to a machine tool.
Female—A recessed or internal portion of a fitting, as a female gauge, or female screw.
Fine Feed—A small amount of traverse imparted to a tool in a machine.
Finishing Cut—The removal of the last portion of metal from a piece of work, being usually a slight amount.
Fitting—The minor adjustments of pieces of work previously prepared in other departments.
Flange—An expansion or extension on a casting or forging, used as a means of attachment with screw bolts.
Flesh Side—The rough side of leather belts.
Following Steady — A travelling stay. See *back steady*.
Form, or Former—A templet or guide by which a tool is controlled in producing work of irregular outlines.
Fractional Pitches—In screw cutting, pitches which are not aliquot parts of the pitch of the lead screw of the lathe.
Frosting—Light scraping done at various angles for good appearance.
Full — Signifies that a dimension is slightly over an absolute dimension.
Full-size Drawing—One that represents the actual dimensions of an object.
Full Thread—A thread which is cut to its proper depth.

GAS THREADS—Screw threads of finer pitch than the Whitworth, and made in a much smaller range of number of threads per inch.
Gauging—Measuring work by methods of contact instead of by a rule.
Gears—Any arrangements for the production of motion, as belts, toothed wheels, valve motions, etc.
Gear Wheels—Toothed wheels.
Glut — A block by which pressure is imparted, or by which wear is taken up, or a false key.
Grain Side — The smooth side of leather belting.
Grinding—Usually understood as that done on emery-wheel grinding machines with precision movements.
Grindstone—Used chiefly for grinding cutting tools with single edges.
Gromet—A washer made of spun yarn, in the form of a ring, used in making water-tight joints under boltheads.

HACKING—Truing a grindstone with a chisel-like hammer.
Hard Metal—Metal which is tooled with difficulty.
Heating — The rise in temperature of journals and their bearings, due to insufficient lubrication.
Heavy Cut — A deep cut, combined with a coarse feed.
High-speed Tools — Tools of self-hardening steel that cut rapidly, and which are not injured when working at a high temperature.
Honing—Imparting a fine edge to a cutting tool on a hone or oil stone, subsequent to grinding.
Hub—A *boss*.
Hunting Cog—An extra tooth in one gear wheel of a pair, to prevent the same teeth coming together regularly into engagement.

IDLER or **IDLE WHEEL** — One which changes the direction of motion or fills a space, without affecting velocity ratios.
In Gear—Toothed wheels having their teeth intimately engaged are in gear.
In Line—Signifies numerous centres or facings in one horizontal plane.
Insertion—Sheets inserted between flanges to render metallic joints steam tight.
Interchangeable—The fitting of identical parts as they leave machines, without any correction by hand.

JACKING UP—The lifting and adjusting heavy work through small distances by the erectors.
Jam Nut—A lock nut.
Jenny—A short crowbar, or pinch bar.

KEYING UP — Securing wheels and pulleys to their axles by the insertion of keys.
Key Bed, or Key Seat—The groove formed for the reception of a key.
Keywaying—Cutting keyways.
Kink — An abrupt bend or angle in a piece of metal.

LAGGING—Covering engine cylinders with a casing of sheet metal, or of strips of wood.
Lap — A body of lead, tin, or wood charged with emery powder.
Lapping—Grinding and polishing by means of a lap.
Lath—A strip of wood used for taking a dimension.
Lathe Dog—A *carrier*.
Lathe Work—The work of the turnery.
Lead Hammer—Used for hammering polished metal without bruising it.
Lead Screw—The lathe screw, the pitch of which is the first factor in screw cutting.
Left Hand—Relates to the direction of some screw threads, of spirals of drills, and of bending in single-edged tools.
Light Cut—The removal of a small quantity of metal in a machine.
Lining Off, or Lining Out—Marking the working lines on castings and forgings as a guide for the turners and machinists.
Live Spindle—A spindle which rotates. Specifically the spindle of a lathe driving headstock.
Loose Centres—Machine centres.

MACHINE TOOL—A machine by which cutting tools are operated by power.
Machining — Cutting metal by the aid of machine tools of all kinds.
Main—The principal element, as main belt, main pulley, main screw, etc.
Male—An external element, as a male gauge, male screw.
Mandrel, or Mandril—A spindle on which bored work is carried for turning. Also an *arbor*. The lathe spindle.
Marking Off—The same as *lining off*.
Marking-off Table — A cast-iron table, on which work is marked out.
Milling—Shaping metal with milling cutters. Knurling the heads of screws.
Multiple Cutting — Machine operations employing several tools simultaneously.

NOSE—The front end of a spindle or mandrel.

OIL FEED—The means adopted for feeding oil to bearings.
Oil Grooves—Grooves cut in the faces of journal bearings to distribute the oil over the journal surface.
Out of Gear — Toothed gears having their teeth disengaged.
Out of Truth—Denotes a condition of inaccuracy in work.
Over All—A dimension which is the sum of numerous smaller dimensions in one plane.

PICKLING—Immersing castings in dilute sulphuric and nitric acids to remove scale previous to machining.
Pitch—The distance between centres of adjacent wheel teeth measured on the pitch line.
Pitch Chain — Chain composed of flat links. Used for much machine driving.
Pitch Line—Corresponds with the velocity lines of toothed wheels.
Plumb—Truly vertical.
Poker Filing—Draw filing.
Press Fit—A fitting of parts that requires considerable pressure.
Prising—Turning or moving an object with a crowbar.

RAKE—The angles of cutting tools; as front, bottom, or side rake.
Reamering—Smoothing and finishing drilled holes with reamers.
Reboring — Smoothing, with enlargement of the bores of cylinders which have become inaccurate by wear.
Rechucking — Putting work into a new position in a lathe chuck to present a fresh portion for turning.
Resetting—Turning a piece of work into a new position in a machine to present a fresh portion for tooling.
Roughing Cut—A first cut taken on a casting or forging. It is coarse and heavy by comparison with the finishing cut.
Rust Joint—A water-tight joint made between iron and iron. Iron borings and sal-ammoniac are used.

SCRAPING—A finishing operation following filing, or planing. It is adopted when very true plane surfaces are required, as for machine slides.
Screw Cutting—Generally denotes the cutting of screws in a lathe, with a single tool.
Screwing—The cutting of screws with dies in stocks, or in screwing or automatic machines.
Scribing—Marking lines with a scriber point held in the hand, or in a scribing block, or surface gauge.
Self Acting — Relates to automatic movements in machine tools.
Sliding Fit — A mutual fitting of parts which permits of easy sliding, but without appreciable slackness or slop.
Soapsuds—Soft soap used for the lubrication of cutting tools.
Soda—Used in water for the lubrication of grinding work to prevent rusting.
Solid Tools — Tools with shanks, as distinguished from cutters.
Speeding—Calculating the speeds of pulleys, gears, and their sizes.
Sponge Cloths—Used for wiping oil from machines and work.
Straining Line—A fine wire strained between points to obtain a true plane test, for setting or checking the alignment of objects.
Surfacing—The same as *facing*.

TAKING UP—The making of adjustments to compensate for the wear of slides and other elements.
Tapping — Cutting internal screw threads with screw taps.
Tapping Hole—A hole drilled to the size of the bottom of a screw thread to be cut in the hole. Also the operation of cutting the thread.
Templet—A pattern from which a piece of work is lined out or machined.
Tommy—A round bar used for insertion in the holes in circular nuts to turn them by.
Tool Holder—A bar for holding and operating loose cutters.
Transverse Cut—Cutting done at right angles with the axis of a piece of work.
Truth—Accuracy in machining and fitting.
Turning—Includes the production of all plain external cylindrical surfaces, and plane faces in lathes of all kinds.
Turnings—The shavings and comminuted chips removed in lathes.
Turret Work—All work done in turret lathes and automatics.

VEES, VEE STRIPS—Angular strips by which adjustments are effected to compensate for wear.

WIRE EDGE—The slight arris which is turned over in sharpening a cutting tool.
Work—Commonly used as a noun, to denote any piece on which operations are being performed.

MACHINE TOOL PRACTICE

SEE ALSO MACHINE AND FITTING-SHOP TERMS

ADJUSTING SCREWS—Used for moving slides and for setting parts to definite positions.

Aligning — Getting parts in line, such as lathe spindles, etc.

All-gear Head—A lathe head without belt stepped cones, but gears only, to obtain the speed changes.

Apron—The part of a lathe carriage which hangs down in front and carries the clasp-nut and gears for sliding and surfacing.

Axle-grinding Machine—A design somewhat resembling that of a lathe, but with two grinding heads instead of turning rests.

Axle-turning Lathe—Used for rapidly finishing railway axles, usually turning both journals simultaneously.

BABBITT METAL — Employed largely for spindle bearings.

Back Centre—The hinder centre on the poppet in lathes and grinders.

Back-gear—Toothed wheels used to gain power and transmit it back to a spindle.

Backing-off Lathe—One with a reciprocating slide-rest, to cut the clearance behind the teeth of cutters.

Backshaft — The feed-shaft when placed at the back of a lathe-bed.

Ball-turning Rest—A swivelling slide-rest for turning spherical portions.

Band-saw Machines—Largely employed for cutting metal.

Bed—Any base or lower portion on which slides are set or moved.

Bell Chuck—A hollow chuck in which work is gripped with a number of set-screws set radially. Also termed *cup chuck*.

Belt Polishing Machine—A type on which runs an endless belt charged with polishing material, adapted to go into curves which could not be touched by wheels.

Belt Shipper—A handle moving forks which "strike" or push a driving belt from one pulley to another.

Bench—A prefix applied to certain small machines, as bench drilling machine, bench lathe, bench grinder, which are not fastened on independent standards.

Bevel Gear Cutting Machines—These use either rotary cutters or, with more accurate results, planer tools.

Bolt-screwing Machine, or Bolt Cutter—One which cuts the threads on bolts, revolving in a spindle, by means of dies in a sliding carriage, or vice versâ.

Boring—Performed either in the lathe or in special machines.

Boring Bar—A cylindrical bar in which boring cutters are fixed. The bar may have a large head to carry cutters; the head may slide instead of moving the work.

Boring Head—A cylindrical head carrying a number of cutters around its periphery.

Boring Lathe—One used for preparing wheels for turning. It only bores and faces the hub. A slide-rest or a special poppet is fitted.

Boring Machines—Either of horizontal or vertical types, with one or several spindles.

Boring Mill—A lathe having its axis vertical, with table, and cross-rail carrying a tool-saddle.

Boring Rest—Used to steady and support either work or boring tools.

Box Tools—Cutters held in cast-iron boxes with steadies to ensure uniform results in turning.

Brass-finisher's Lathe—A type of lathe with a chasing rest, and usually a turret.

Breaking Piece—A pin or portion introduced into mechanisms, such as planers, to shear off when a dangerous strain accidentally comes on the driving gears.

Break Lathe—One with a wide gap, and an extra rest mounted on a pillar by the face plate, besides the rest and poppet on the bed.

Broaching—Smoothing out round holes with broach or reamer. In America the word means *drifting*, and broaching machines are employed.

Bush Grinder—A machine for lapping or grinding out bushes in hardened work, with a grinding wheel.

CABINET LEGS—Machine standards which are cast as cupboards for the reception of tools, etc.

Cam Cutting Machines—Either milling or grinding machines using formers.

Capstan Rest—A tool-rest carrying several tools in a circle. Also termed a *turret*.

Centring Machines—For drilling centre-holes in shaft-ends preparatory to turning or grinding.

Chamfering Machine—A type of lathe employed to chamfer or bevel nuts and bolt-heads.

Change-wheels—Toothed gears used to obtain speed ratios in screw-cutting, etc.

Chasing Lathe—One used for the production of screws by a die, or with tools traversed from a hob.

Chuck—Any appliance used for gripping work to be tooled.

Chucking Lathe—A face type of lathe employed for tooling objects held in a chuck by one end only.

Chucking Tools—Long drills and reamers used in *chucking lathes*.

Circular Milling Machine—A design in which wheels, etc., are rotated, and cut by milling cutters, instead of turning in the lathe.

Circular Motion—A fitting on a shaper which rotates to shape curved pieces.

Clamping Plates—Employed on most machine tools to hold work securely during tooling, or to grip the tools in their rests.

Clasp Nut—A divided nut which may be disengaged at will from a guide screw.

Cold-iron Saw—A circular saw, rotating at moderate speed (unlike the hot-iron saw), for sawing castings and forgings.

Collet—An intermediary fitting to hold cutters, drills, dies, etc., in spindles.

Combination Chuck—A lathe chuck, the jaws of which can be operated independently or simultaneously at will.

Combination Machines—Those which are capable of performing various operations, instead of only one, as boring, drilling, and milling, planing and grinding, planing and slotting.

Compound Rest—A slide-rest with superimposed slides, affording movements in two directions.

Concentric Chuck—One in which the jaws are moved simultaneously. It is also termed *self-centring*.

Cone-plate—A form of steady-rest, comprising a disc bored with differently-sized taper-holes and mounted on a bearing-pin. It is set upright facing the lathe-head, and one taper-hole receives the end of a piece of work, which is then drilled.

Countershaft—An intermediate shaft with belt pulleys by which speed changes are obtained, and machines started and stopped.

Cut-off Rest—A transverse rest used in capstan lathes to part off work.

Cutters—May be turning tools held in a bar, boring tools, facing tools, or milling cutters.

Cutting-off Machine—A type evolved from the lathe. It has a hollow spindle and a cross-slide, parting off shafts and bars with perfect accuracy.

Crankshaft Lathe—This is a massive form, with a number of slide-rests.

Cylinder-boring Machine—Either of horizontal or vertical design, the latter being preferred for very large bores.

DEAD CENTRES—Those which do not revolve, as opposed to live centres.

Diamond Tools—Diamonds are employed to true up grinding wheels of emery, corundum, carborundum, etc.

Die—A screw-cutting appliance used in machines.

Die-head—One which holds several chasers radially, these being removable for sharpening, and may sometimes release or move outwards to clear the thread after cutting it.

Disc Grinders—Machines employing discs of steel upon which sheets of abrasive cloth are cemented. Very accurate results may be obtained in this manner.

Dividing Head—A fitting which has provision for locking a spindle in a number of positions, representing divisions of the circle; used for tooling polygonal objects and for cutting gears on the milling machine. Also termed *index centres*.

Division Plate—A disc fitted to a lathe-head, or a dividing head. It has several circles of holes to effect divisions around a circle.

Dog Chuck—A chuck with jaws moving in slots.

Double—This prefix is placed before many types of machines having double heads or spindles, etc., or possessing double-acting mechanism to increase output.

Drifting—Finishing out holes of square or other shape with a drift, having serrations, or teeth, forced through the holes by power.

Drill—A tool which originates holes; flat, fluted, and twist-drills are the principal.

Drill Chuck—A small chuck with long jaws operated concentrically.

Drilling Machines—May be of vertical or horizontal designs, with one or more spindles, provision for angling, hand or power feeds.

Duplex—This is a term applied to machines when portions are duplicated, as duplex rests.

EDGE MILL—A milling cutter that acts by teeth on its sides. Called also a *side mill*.

Elliptic Chuck—A special lathe chuck possessing a sliding portion, by which elliptical objects are turned or bored. Erroneously called *oval chuck*.

End Mill—A milling cutter operating by its end teeth, as distinct from an *edge mill*.

Ending Machine—The same as a *rotary planer*; employed for trimming the ends of large girders and columns, etc.

Engine Lathe—One of complete type, for sliding, surfacing, and screw-cutting.

FACE LATHE—One that has no poppet, work being held on the plate or chuck only.

Face Mill—An *end mill*, but of large diameter.

Face Plate—The disc screwed on the lathe spindle nose, and slotted to receive holding-down bolts.

Facing Arm—This is an attachment to a boring bar, by which the end portions of bored work are faced across.

Feed Mechanisms—Devices employed to feed slides or spindles at definite rates. Belt-cones or gears or friction wheels are used to effect the necessary changes.

Fixture—An appliance for setting and holding a piece of work on a machine in a definite position, which may be repeated exactly for other similar pieces. *Jig* is another name. Some, as for drilling, have guide bushes to control the position of the drills.

Flexible Shaft—Used in connection with portable machine tools, driving them in any position by the flexibility of the shaft, which is produced by coiled wires or a number of joints.

Floor Plate—A large tee-slotted plate on which massive work is laid and tooled by portable machines shifted about, and bolted anywhere on the plate.

Forge Lathe—A massive lathe employed for turning forged work, as shafts, etc.

Forming—Turning irregularly-shaped pieces with tools of the same profile.

Frame-plate Slotting Machine—This is a special type for locomotive work, having several slotting heads above a long table on which a pile of frame-plates are laid.

Friction-clutch—Employed extensively in machine-tool work, both for countershafts and in machine construction, for throwing movements in and out quickly.

GANG—Applied to a set of tools, such as gang mills, which are built up of several separate cutters.

Gap Lathe—A lathe with a break in the bed to receive large objects.

Gear-cutting Machines—These employ either rotary cutters or reciprocating planer tools. Teeth are pitched out with dividing wheels, or worm wheels. Machines are semi or entirely automatic. Teeth derive their shape from the cutters, or from formers or templets, or are generated by the mechanism embodied in the machine.

Grinding Machines—Those employing rotating wheels, and used for finishing plane surfaces, curves, holes, and cylindrical portions. Either the work or the wheel may move, or both.

Grinding Wheels—Wheels of emery, corundum, carborundum, or alundum, used in grinding machines.

Gun Lathe—A very heavy type for turning and boring guns. Steady rests are employed to support the great weight.

HACK-SAW MACHINE—A reciprocating type, carrying an ordinary blade; it has a vice to hold work.

Hand—Applied to hand-operated mechanisms, as hand-drill, hand-feed, hand-lathe (one with plain slide-rest).

Headstock—The driving head of a lathe or grinder. Also called the *live head, fixed poppet head, or fast headstock.*

High-Speed—Relates to the abnormal speeds possible by the use of high-speed steels. Lathes and other machines are much modified in driving and feeding details and strength of parts.

Hob—A short screw which guides the nut in a chasing lathe. Also a cutter for producing worm-wheels. A master tap over which screwing dies are cut.

Hobbing—Cutting worm and spur gear teeth by a rotating hob, the gear blank rotating continuously.

Hollow Drill—Made so in order to pump oil through to the cutting point and wash out the chips.

Hollow Mill—A hollow cutter which passes over a bar and reduces its diameter; usually held in a turret.

Hollow-spindle Lathe—One with a hole bored right through the spindle, to pass bars, which are turned and cut off. Spring chucks are placed on the nose.

Horizontal—A prefix used in connection with drilling, boring, and milling machines which have their spindles lying horizontally.

INDEPENDENT CHUCK—A chuck, the jaws of which can be moved independently of each other.

Indicator—An instrument which magnifies error in machine movements and enables delicate tests to be made.

KEYSEATER, or KEYWAY CUTTING MACHINE—An adaptation of the slotting machine, for cutting keyways in wheel-bores. It has a reciprocating tool.

LAPPING MACHINE—A kind of lathe which revolves a lap, charged with abrasive powder; used for truing out holes.

Lathe—A machine which rotates work upon a plate or chuck, or between two centres, and cuts with turning tools.

Lead Screw or Leading or Guide Screw—The master screw of a lathe, by which threads of various pitches are produced.

Line Shafting—The main shafting driven by the prime mover, and from which countershafts are belted.

MACHINE VICE—A vice with movable jaw, to hold pieces of work for tooling.

Magazine Feed—A mechanism which feeds separate pieces of work into a machine, instead of employing an attendant.

Mandrel—The spindle of a lathe-head. Also a separate spindle on which work is held for tooling. A mandrel press is used for forcing work on and off.

Milling Machine—One which employs rotary many-toothed cutters.

Multiple-spindle Drilling Machine—One with several spindles to drill a number of holes simultaneously.

NEST GEAR—A set of toothed gears mounted in such a manner that changes of speed can be obtained by different combinations.

Nut Lathe—Used for facing and chamfering nuts, held on a mandrel.

Nut-tapping Machine—A machine using long taps, which pass through the nuts until a string of them is done.

OIL—Used for lubricating machine parts and cutting tools.

Open and Crossed Belts—A means of reversing the motion of a pulley.

Open-side Planer—A planer in which one standard is omitted, leaving space for large work to project over the table.

Open-spindle Lathe—A *hollow-spindle* type, with a large slot into which the operator's hand reaches.

PIT PLANER—A large style of planer, in which the housings and rail travel over work supported in a pit.

Planing Machine—A reciprocating type of machine, in which the work usually travels on a massive table under the tools; sometimes the tools move.

Poppet—The loose headstock of a lathe or grinder. Called also the *tailstock, footstock,* or *sliding head.*

Profiling Machine—A milling machine, the cutter slide of which is controlled by a form resembling the work outline.

Pump—Used for supplying oil or suds under pressure to cutting tools.

QUARTERING MACHINE—Employed for drilling the crank-pin holes at right angles in locomotive wheels after they are pressed on their axles.

Quick Return—The rapid backward motion of slides during the non-cutting stroke.

RADIAL DRILL—A drilling machine having a pivoted arm, enabling the drill to be moved about over the work.

Reamer—A fluted tool used to finish drilled holes.

Rotary Planer—A form of milling machine using a large face cutter with inserted teeth.

SADDLE—A sliding portion which carries other slides or rests.

Screwing Machine—Either a bolt-screwing machine or a pipe-threader.

Screw Machine—A type distinct from the above. It possesses turret and rest, and turns and cuts off the work.

Screw-milling Machine—A recent development by which screws are milled instead of being turned.

Sensitive Drill—A small type, the spindle of which is fed by hand lever.

Shaping Machine—A machine in which the tool is carried in a reciprocating ram passing over the work-table.

Side Planer—Resembles a shaper, but the head travels along the bed, taking a long cut on the end of work too big to go in the ordinary planer.

Slot-drilling Machine—Used for cutting keyways and cottar-holes by a revolving cutter, endlong motion producing a slot.

Slotting Machine—A vertical ram machine with horizontal table.

TAPPING MACHINE—This operates taps for nuts, etc. A sensitive device obviates breakages.

Tool Grinders—Include those for lathe and planer tools, cutter grinders, and drill grinders.

T-slot or Tee-slot—This special shape is employed to enable bolts to be slid into any position for clamping work on tables.

Tyre Lathe—Used for boring and turning railway wheel tyres.

UNIVERSAL—Used in connection with certain machines which embody very complete movements, as universal millers, universal grinders, distinguishing them from simple or "plain" machines.

Universal Joint—A pivoted joint employed to transmit motion to portions which are not stationary.

VALVE CHUCK—A lathe chuck having jaws by which a several-faced object may be turned successively into several positions for tooling.

Vertical—Applies to the position of spindles or rams, as in vertical drills and boring machines, vertical lathes or boring mills.

WALL—Used to denote wall-drilling machines, wall planers, etc., which are not self-sustaining.

Wheel Lathe—A special kind used in locomotive shops for boring and turning wheels.

MOTOR ENGINEERING

SEE ALSO PRIME MOVERS AND TRANSIT

ACCELERATOR—A pedal acting on the throttle which controls the supply of gas to the engine.

Accidents—May arise from many causes, a car being a complicated mass of mechanism. A chauffeur must be qualified to deal with all emergencies on the road. See specific headings.

Accumulator—Two accumulators provide a storage of electricity on a motor-car. They have a voltage of about four—a little above or below.

Ackermann Axle—One having pivoted arms.

Advance Spark—Timing the ignition so that the explosion is generated before the piston quite reaches the top of its stroke.

Air-cooled Cylinder—The cylinders of motor cycles and some light cars are air-cooled.

Automatic Valve—An inlet valve which is moved inward by the explosive mixture, in opposition to a partial vacuum produced in the cylinder on the outstroke. The term is used to distinguish it from a valve which is operated by mechanical means.

BACK-FIRE—An explosion which, happening at the wrong time, tends to run the engine in the way opposite to its proper direction.

Balance—The throws of a crank shaft are counterbalanced to prevent injurious vibrations.

Brake—Two kinds of brakes are used on cars—the band and the expanding type. One brake acts on the gear shaft, and one each on the driving wheels. The engine is also used as a brake on steep hills.

Burst Tyres—May be mended temporarily by lacing a gaiter on.

CAM—A projection which is eccentric in relation to the axis of the cam shaft.

Cam Shaft—The half-speed shaft which carries the cams for mechanically operated valves. The cams are formed solidly with the shaft.

Carburetter—The apparatus in which air for combustion, sucked in with the piston, draws with it a spray of petrol. Termed a carburetter because the air is carbonised.

Cardan Shaft—The second or universal shaft, driven by change-speed gears, which drives the back axle.

Changing Gears—Gears must only be changed when the engine is not driving the car. It must be disconnected from the gear by the friction clutch operated by a pedal.

Change-speed Gears—The fixed and sliding series of gears by which the speeds of a car are changed though the engine may run at normal speed.

Change-speed Lever—The lever in the right hand of the driver, which is locked in notches in the quadrant, for the three forward speeds, a neutral or out of gear position, and the reverse.

Chassis—A car with its engine and machinery ready for the body work of the coachbuilder.

Chauffeur (Fr.)—Literally, a stoker or fireman.

Clutch—In a car it forms the connection between the crank shaft of the engine and the gears which drive to the rear axle.

Coil—The current from the accumulator passes through a coil to produce the high tension spark for ignition, passing round the primary and the secondary or high tension wire.

Commutator—A term often applied to the contact-breaker.

Compression—Produced by the in-stroke of the piston, and necessary to yield a powerful explosion.

Compression Cock—Used to release compression when the engine is being turned round by hand for cleaning. Also for injecting paraffin oil to make a stiff piston move easily.

Compression Stroke—The instroke of a piston which compresses the explosive mixture. This may be about equal to 80 lb. per square inch.

Contact Breaker—The apparatus by which electric contact is made and broken between the coil and the engine. Its drum can be adjusted to make contact early or late.

Cooling Water—Only soft water should be used; hard will cause a deposit and check the circulation.

Crank Case—The casing under the engine containing the crank shaft. It is usually an oil reservoir.

Crank Pin—That portion of the throw of the crank which is embraced by the big end of the connecting rod.

Crank Shaft—The main shaft which receives its motion from the connecting rods and pistons.

Cylinder Deposit—A carbonaceous deposit which is liable to accumulate from the petrol and lubricating oil. It must be scraped out.

DEFLATION—The escape of air from a tyre. May be caused by puncture, or is done when a tyre has to be removed.

Densimeter—See Hydrometer.

Differential Gear—Equal bevel wheels connected by bevel pinions, without shafts, and rotated in a case, so that the wheels may rotate faster or slower when going round corners.

Direct Drive—Signifies driving done at the highest speed without going through gear wheels.

Drop Feed Lubrication—Feeding oil by gravity through tubes distributed to the bearings. Also termed sight-feed lubrication.

ENGINE BRAKING—Using the resistance of the movements of the engine to check the movement of a car.

Engine Stopping—This may be caused by choking of the carburetter, or by short circuiting, or a faulty coil, or a broken connection, or the pistons may seize.

Exhaust Stroke—The instroke of a piston which ejects the burnt gases from a cylinder.

Exhaust Valve—The valve in the head of a cylinder through which the burnt gas escapes into the air.

Explosive Stroke—The outstroke of a piston which is produced by the explosion of the mixture of vapour and air behind it.

FAN—The cooling of the water in the radiator is assisted by a fan revolved behind the radiator, and driven by the crank shaft. Frequently the fan blades are formed in the fly-wheel.

Fierce—The equivalent of seizing as applied to a clutch.

Firing—Exploding the charge in a cylinder. It takes place rather before the piston reaches the end of its compression stroke.

Float Chamber—One of the chambers in a carburetter in which a float maintains the petrol at a uniform level.

Flooding—A carburetter is flooded when the petrol runs over. Also signifies admitting petrol in excess for the purpose of starting the engine.

Fly-wheel—Is carried by the crank shaft and receives the transmission clutch.

Forced Lubrication—Is effected by a valveless pump which supplies oil under pressure to the bearings of the engine parts, etc.

Four-cycle—Inspiration of the gas, followed by compression, explosion, and exhaust.

Freezing—Frost is liable to crack motor cylinders if water is left in them, and to prevent circulation in the radiator.

French Chalk—Used to prevent the inner tyre tube from sticking to the covering tube.

GATE CHANGE—The alternative of the notched quadrant method of changing speed gears. The lever moves through slotted gates, so that the gears cannot miss.

Gear Box—The case which contains the change-speed gears, and the lubricant in which they run.

Gear Teeth Stripping—The tearing off of portions of teeth consequent on wear, or on throwing them in without disconnecting the engine shaft from the driving axle.

Gills—The ribs cast on the cylinders of motor cycles to increase the air-cooling surface.

Governor Control—The movements of the throttle valve regulated by the revolving weights of the governor, controlled by driver's hand or foot.

Gravity Feed—System of running petrol from a tank placed above the carburetter.

Gudgeon Pin—The pin which unites the small end of the connecting rod to the piston, and around which the rod pivots.

HALF-TIME SHAFT—The cam shaft which lifts exhaust valves. So called because it runs at half the speed of the crank shaft, from which it is driven by toothed gears.

Hand Starting—Starting an engine by turning a lever to introduce the explosive mixture and compress it, without which ignition cannot occur.

High Tension Current—The current coming from the secondary coil which gives the spark necessary for igniting the explosive mixture in a cylinder.

Hydrometer or Densimeter—A glass tube weighted at its lower end, and marked for different specific gravities, water being 1. It is used to test the sp. gr. of petrol or other oils.

IGNITION—The electrical means adopted for firing the charge in the cylinder head.

Inlet Pipe—The pipe conveying the gas from carburetter to inlet valve.

Inlet Valve—The valve in the head of a cylinder through which the petrol vapour and air are sucked in.

Instroke—The movement of a piston towards the cylinder head from the direction of the crank shaft.

Insulation—Is absolutely necessary in conducting the high tension current from the induction coil to the sparking plug. Insulation is of thick rubber, and enclosed in a tube of brass or vulcanite.

KNOCKING—Is produced by want of alignment in the crank shaft, so that the shaft does not lie at right angles with the piston rods. The remedy is to pack up the lower bearing. There are other causes, as loose bearings, or deposit on the top of the piston.

LIGHT OIL—An oil which has a specific gravity much below that of fresh water. Thus, petrol has a sp. gr. of 0·70 to 0·72, water being 1. If greater than 0·730, it is not suitable.

Live Axle—One which rotates with its wheels, as distinguished from a dead axle, which is fixed, and on the ends of which the wheels revolve.

MAGNETO—A small electrical machine frequently preferred for ignition to the accumulators and coil. It includes armature, pole-pieces, condenser, and connections.

Magneto Drive—This is effected from the engine by the half-time shaft.

Mechanically Opened Valve—An inlet valve which is opened by a cam and levers, as distinguished from an automatic valve.

Miss-fire—Occurs when the sparking plug does not work owing to short-circuiting.

Miss-gear—Signifies the failure to get gears into mesh.

Mushroom Valve—The lifting type of exhaust valve, comprising a disc fitting on its seating and a stem surrounded with a spring and actuated by the cam on the half-time shaft.

NEEDLE VALVE—A slender valve which shuts off the supply of petrol to the float chamber of a carburetter, and which is controlled by the vertical movements of the float.

Negative Plates—These in an accumulator become, with use, of a grey tint.

OIL PUMP—This is either a hand pump or one worked from the engine to lubricate bearings.

Otto Cycle—Comprises two outstrokes and one instroke for each explosion, namely: (1) sucking in explosive mixture; (2) compressing; (3) firing; (4) exhausting.

Outstroke—The movement of a piston away from the cylinder head in the direction of the crank shaft.

Overheated Cylinders—May be due to an insufficient supply of water in the circulating system, or a radiator having too small a surface, or to a lack of air supply to the petrol, or too little cylinder lubrication, or to a delay in the ignition, each requiring its own remedy.

Overheating of Parts—Is due to many causes. See specific headings.

PETROL—The lighter first distillations from petroleum, or rock oil.

Petrol Taking Fire—This cannot be extinguished with water, but with sand or a chemical extinguisher.

Petrol Tank—Must not be filled near a lamp, or the vapour will ignite.

Platinum—The contacts of contact-breakers are tipped with platinum to prolong the wear.

Pneumatic Tyre—Comprises the inner tube, which is inflated, and the outer cover, which receives the pressure.

Positive Plates—These in an accumulator become, with use, of a reddish-brown colour.

Punctured Tyre—Is mended with a patch of indiarubber and rubber solution, the surface surrounding the puncture being first cleaned with glass-paper.

RADIATOR—The series of piping and grills in front of a car through which the hot water from the cylinder circulates and is cooled by the air.

Radius Rods—Rods which are attached to a cross-piece on the car body at one end, and to the top and bottom of the bevel gear case of the back axle at the other. They check the tendency of the gear case to turn round the axle.

Ratchet and Pawl—Fitted to a gear brake drum to prevent a car from running backwards.

Reverse Gear—The intermeshing of three gear wheels in the gear box so that the forward motion of the engine is converted into a backward motion at the road-wheels.

SCROLL IRONS—The irons attached to the frame of a car which receive the links that carry the ends of the springs.

Second Shaft—The one which is driven by the change speed gears, and drives the back axle, to distinguish it from the first or engine shaft.

Security Bolts—Bolts with flat heads which hold the covering tyres in place in the central position, so reinforcing the grip of the beaded rims.

Seize, Seizing—The tearing up of the particles of metal between surfaces in contact, caused by their too intimate intermixture.

Self-firing—Ignition in a cylinder produced by the heat caused by the presence of cylinder deposit, and which occurs without the spark.

Side-slip—Is caused chiefly by greasy roads, by the camber of the road being too high, or by turning corners too quickly.

Silencer—The box through which the exhaust gases pass to the atmosphere, and in which they are expanded before being discharged.

Spares—Duplicates of the small, more vital parts of a car which are carried to enable temporary repairs to be made on the road.

Sparking Gap—The space between the end of the high tension wire and the sheath of a sparking plug. It measures about one-sixteenth of an inch.

Sparking Plug—Conveys high tension current to the inside of the cylinder to fire the explosive mixture. The plug itself is a non-conductor of porcelain contained in a sheath of metal screwed into the cylinder.

Splash Lubrication—Signifies the lubrication of crank and engine parts with oil contained in the crank case, which is splashed up by the revolutions of the crank within it.

Sprag Wheel—A ratchet wheel.

Spray Carburetter — Specifically, the present type in which the petrol is sprayed, to distinguish it from an old form of surface carburetter in which petrol was absorbed by air passing over its surface.

Spray Chamber—One of the chambers in a carburetter up which the petrol is drawn through a nozzle from the float chamber by the induction of the air.

Spring Ring—A piston ring is thicker on the side opposite the split, to increase its elasticity.

Sprocket Drive—Used when each road wheel on the back axle is driven separately from a shaft driven by differential gear in the gear-box.

Steel Tyre—The flat rim of steel attached permanently to the wooden felloe of a wheel.

Steering Gear—The mechanism by which the movements of the front wheels of a car are controlled. By the turning of the hand-wheel, a worm moves the worm-wheel segment, and thence levers actuate the wheels.

Steering Pillar—The inclined pillar in front of the car driver which carries the steering shaft, its hand-wheel at the top, and worm at the bottom.

Steering Wheels—The front wheels of a car, which are pivoted to the ends of the front axle.

Stub Axles—The short axles hinged to the front axle which carry the bearings on which the wheels revolve.

Studded Tyre—One which is provided with studs to prevent side-slip.

Suction Stroke—The outstroke of a piston which sucks the explosive mixture into a cylinder.

TACKY—Relates specifically to the sticky condition of the rubber solution, consequent on evaporation, with which a patch is cemented on a punctured tyre. When the solution has become tacky, the patch and tyre are pressed together.

Thick Oil—The oil used for the lubrication of engine parts.

Throttle Valve—A disc valve in the pipe leading from the carburetter to the engine. By regulating its movements the explosive mixture is admitted to, shut off from, or partly controlled to the engine.

Timing—The spark is retarded when starting an engine, and accelerated when running with speed.

Timing Ignition—In the mechanically operated valves this is done by setting the valves and the camshaft pinions. The inlet valve is set to begin to open when the piston is at the top end of the cylinder, and the exhaust valve to be shut when the inlet valve begins to open.

Torque Rod—A hinged member designed to resist any independent circular movement of the hind axle.

Transmission Clutch—The clutch by which connection is made and broken between the engine shaft and the change-speed gears.

Trembler Coil—An induction coil which is provided with mechanism by which it is rapidly interrupted, so that the contact is made and broken, and the sparking produced very quickly.

Tyre Bead—The thickened edges of the outer or covering tyre which are forced into the flanges of the steel rim.

Tyre Pressure—The pressure for inflation varies from 60 to 80 pounds per square inch in smaller and larger cars.

UNIVERSAL SHAFT—The second shaft driven by the change-speed gears, which has a universal joint at each end to permit it to accommodate itself to the movements of the back axle.

VALVE LIFTERS — Rocking levers which make roller contact between cams and valve spindles. They avoid side pressure, which occurs when cams and tappet rods are in contact. Also denote tools used for valve lifting.

Valves Breaking—If the head of a broken valve gets into the cylinder it must be got out with a piece of wire or a magnet, or it will fracture piston or cylinder.

Valves Leaking—This is remedied by re-grinding them on their seatings.

Vee-pulleys—The grooved pulleys on a motor cycle round which the driving belt passes.

Vulcanising—Uniting rubber patches, etc., with the aid of heat.

WATER—Is circulated through the cylinder jackets. If it becomes overheated, the efficiency of the engine is lessened.

Water-jacket—A narrow space enclosing the cylinder walls around which cooling water is circulated by a centrifugal pump drawing from a tank and driven by the engine.

MINING

SEE ALSO GEOLOGY, CIVIL ENGINEERING, AND BUILDING

ADIT—A gallery driven from the open-air into a mine; more particularly the gallery that drains a mine.
After-damp—The atmosphere produced by an explosion of gas in a mine. It consists of carbonic acid, nitrogen, and steam, with a small amount of the highly poisonous carbonic oxide.
Air-box—Wooden tubes for conveying fresh air to workings.
Air-courses—Passages for ventilation.
Air-crossings—Bridged passages for carrying one air-course across another.
Air-doors—Doors for regulating air-currents.
Air-pipes—Pipes for conveying fresh air to workings.
Alloy—A combination of two or more metals.
Alluvial Deposits—Deposits consisting of matter transported by water from higher ground.
Amalgam—An alloy containing mercury.
Amalgamation—The process of the formation of an amalgam; more particularly the use of mercury in the extraction of gold.
Amorphous—Without crystalline form.
Anemometers—Instruments for measuring velocity of air-currents.
Anhydrous—Free from water.
Arenaceous—Containing sand, or sandy.
Argentiferous—Containing silver.
Argillaceous—Containing clay, or clayey.
Assaying—Determining the amount of one or more specified constituents in mining produce.
Attle—Waste rock.
Auriferous—Containing gold.

BACKING DEALS—Planks placed vertically behind the curbs in a shaft to hold back loose fragments
Backs—The unworked portion of a vein above a level.
Bank—The surface land surrounding the mouth of a shaft.
Banket—Auriferous conglomerate consisting of quartz pebbles in a siliceous matrix.
Banksman—The man who receives the tubs at the top of the shaft.
Bar—See *crowntree*.
Basset Edge—Outcrop.
Battea—A very shallow slightly conical dish used for washing gold-dirt.
Bed—A stratified deposit [see *seam*].
Bed-rock—The rock upon which an alluvial deposit rests.
Bind—Shaley layers interstratified with coal-seams.
Bit—The chisel tip of a drill or the drill itself.
Black-band—An earthy carbonate of iron containing bituminous matter.
Black-damp—Carbonic acid gas, CO_2; *choke-damp*.
Blackjack—Zinc blende.
Black Tin—Dressed tin ore.
Blasting—Breaking away rock by means of an explosive.
Blende—Zinc sulphide.
Blower—A sudden emission of fire-damp in a mine.
Blue John—Fluor spar.
Bonanza—An exceptionally rich and persistent body of ore.
Bonnet—Covering to a cage to protect men from falling stones, etc.
Bord—A road driven in a seam at right angles to the main cleavage planes.
Bord and Pillar—See *pillar and stall*.
Bordways Course—The direction at right angles to the main cleavage planes. Also *on face*.
Bort—Opaque dark diamond.
Brattice—A temporary partition for purposes of ventilation.
Bucking—Crushing ore with the bucking iron.
Bucking Iron—A flat piece of iron with a wooden handle, used for crushing samples of ore.
Bunch—A small body of rich ore.
Bunchy Veins—Veins in which bunches occur.
Buntons—Timbers placed horizontally across a shaft.
Burrow—A heap; dump, or spoil heap.

CAGES—The conveyances consisting of platforms with framework used for transporting men, mineral, and material up and down a shaft.
Cap—A piece of wood placed on a prop in timbering. Also called *lid*. In metal mining, *bars* are called *caps*.
Caunter Vein—A mineralised cross-course.
Chimney—A continuous body of ore of moderate width but prolonged in depth.
Chocks—Stacks of pieces of timber laid horizontally with the alternate layers at right angles; also *cribs* or *cogs*.
Choke-damp—Carbonic acid gas, CO_2; black-damp.
Cleat—The more prominent cleavage in a coal-seam.
Cleavage—Planes of weakness in minerals and rocks along which they break up with comparative facility.
Cobbing—Removing adhering ore from pieces of veinrock with a hammer.
Cogs—*Chocks*.
Contact Vein—A vein lying between rocks of different character.
Conveyor—A running belt—very often used for removing coal from the face to the main haulage road.
Corves—The small waggons or cars used for the conveyance of minerals, etc., in mines; also called *trams* or *tubs*.
Costeaning—Seeking deposits by sinking shallow pits and connecting them by an underground gallery.
Country—The rock or rocks in which a vein occurs; also called country rock.
Course—See *strike*.
Cradle—A wooden box with sieve mounted on rockers, used to wash gold-dirt.
Creep—The forcing up of the floor by the pressure of surrounding beds in mine roads and workings.
Crib—Framing timbers in a shaft; also a *curb* or a *chock*.
Cropping out—The appearance of a vein or bed at the surface.
Cross-course—A barren vein having a different direction to the main veins of a district; similar to a fault.
Cross-cut—A gallery driven in the country.
Crowntree—A piece of timber set on props to support the roof; sometimes called *bar* or *cap*.
Curbs—Frames employed as foundations for walling or tubbing in a shaft.

DEAD GROUND—Parts of veins without ore or deficient in ore.
Deadwork—Unproductive work.
Deads—Waste rock; *attle*.
Deputy—Man in charge of a district in a mine.
Development—Operations conducted to render the useful minerals in deposits accessible.
Dial—A pattern of compass used underground.
Dialling—Surveying a mine by means of a dial.
Die—See *stamps*.
Dip—The deviation of the slope of a bed or vein from the horizontal.
Dipping Needle—A magnetised needle swinging in a vertical plane.
Dog and Chain—A device for a withdrawal of timber (props).
Downcast—The shaft through which the downward current of air passes into a mine.
Downthrow—The downward displacement of a seam by a fault.
Dressing—Separating ores from accompanying rock and minerals.
Drift—Any passage underground that is horizontal or nearly so.
Driving—Excavating drifts.
Dropper—A small branch vein on the footwall side.
Dumb-fault—A *wash-out*.
Dump—A waste heap; spoil heap.
Dyke—A vein of igneous rock.

EXPLOITATION—The productive work in a mine.

FACE—The exposed surface of mineral in a working.
Fault—The dislocation of a vein or seam. [See GEOLOGY.]
Feeder—A small branch vein.
Fiery—Containing explosive gas in dangerous proportions.
Fire-damp—Methane or marsh gas, CH_4.
Float Gold—Very finely divided or flaky gold, which floats on water.
Flookan or Flucan—A cross vein filled with clayey matter.
Floor—The stratum immediately below a seam or bed.
Flume—An artificial water-course.
Foot-wall—The under-wall of a vein.
Frame—An inclined wooden slab used in dressing tin ore.

GAD—A pointed wedge.
Gallery—A drift.
Gangue—The worthless portion of the contents of a vein; called also *veinstuff*, *veinrock*, or *matrix*.
Gate—A road kept open in the worked-out part of a mine; called also *gate-road*, or *gateway*.
Gin—A primitive form of winding engine; a whim.
Goaf—The worked-out ground of a coal-mine.
Gob—Same as *goaf*.
Gob-stink—A peculiar smell observed in a pit where spontaneous combustion is taking place; a mixture of higher hydrocarbon.
Gold-dirt—Earthy material containing particles of gold.
Gold-washing—Separating the particles of gold from the dirt by washing with water.
Gossan—The cellular and deeply stained material found at the top of some veins.
Grass—The surface of a metal mine.
Grizzley—A grating.

HADE—The deviation of the slope of a vein or seam from the vertical.
Hanger-on—The man who runs the loaded tubs on to the cage.
Hanging-wall—The upper wall of a vein.
Head Race—Aqueduct for the supply of fresh water.
Heads—The enriched products of ore-dressing. Also see *stamps*.
Headways Course—A direction parallel to the main cleavage planes.
Heave—The lateral displacement of a vein by a fault.
Hewer—The miner who *holes* the coal.
Hitch—A small fault.
Holing—Making the horizontal cut in a seam, usually below it, or in the lower part of it, called *undercutting*.
Horse—A mass of country in a vein.
Hushing—Flushing the surface away with water to expose a hidden deposit.
Hydraulicing—Washing away a deposit into special channels called sluices, by powerful jets of water.

INBYE—Going from the shaft (underground).
Intake—The road along which the fresh air passes in a mine.

JENKIN—A road cut bordways course in a pillar of coal.
Joints—Natural divisions in masses of rock.
Jud—A working place driven in a pillar of coal.
Jigging—A process of ore-dressing and coal-washing in which sifting and water buoyancy act together.
Jumper—A weighted iron or steel bar with chisel end used for drilling holes in rocks by hand.

KIBBLE—A mining bucket.
Kindly—Applied to veinstuff and country; tender, soft, easy, promising-looking rock.
Kirving—Synonymous with *holing*.

LAGGING—Small timber driven behind the main timbering in shafts or drifts to prevent loose fragments falling through.
Launder—Water trough, also a *flume*.
Leader—A branch vein.
Leg—The upright timbers supporting the *cap* in vein-mining timbering.
Levels—Drifts driven along a vein.
Lid—See *cap*.
Lift—Any working place a few yards wide driven in a pillar of coal.
Lode—The profitable portion of a vein, frequently the vein itself.
Long Tom—A wooden sluice used in gold-washing.
Longwall—A method of working by which the mineral is removed in one continuous series of operations.

MAN-ENGINE—An appliance used for raising and lowering men in shafts.
Matrix—The material in which a useful mineral is embedded.
Metalliferous—Containing a metal or metals of the heavier type.
Middles—The intermediate products in ore-dressing operations.
Mineralised—Containing metalliferous minerals.
Mortar—See *stamp*.

NICKING—Making a vertical cut or groove in a face of coal.
Nip or Nip out—A sudden thinning of a seam or vein.

ON END—Headways course.
On Face—Bordways course.
Open-cast—Workings in the open air.
Ore—Mineral worked for the metal it contains.
Out-bye—Towards the shaft (underground).
Outcrop—The part of a deposit exposed at the surface.
Overburden—The surface material covering a deposit of useful mineral.
Overhand Stoping—A system of extracting ore from a vein by excavations made overhead.

PACK, OR PACK WALLS—Pillars of rough waste stone built to support the roof in mining.
Pan—A shallow dish used in washing gold.
Panels or Districts—Areas of a coal-seam isolated by means of barriers of untouched coal, to ensure more agreeable and safer conditions of working.
Panning—The operation of washing gold in a pan.
Parting—An inter-stratified layer of foreign material in a coal-seam.
Pass—A passage kept open for transmitting ore or rock to a level below.
Pay-dirt—The valuable portion of alluvial deposits.
Piling—Sinking shafts through loose ground by driving piles down, behind cribs or curbs.
Pillar—A block of mineral left to support the workings.
Pillar and Stall—A system of working in which the deposit is in the first working cut into blocks or pillars, which are subsequently removed in the second working; also known as *post and stall, bord and pillar, stoop and room*.
Pinch—A vein is said to pinch when it gets gradually thinner, and if it then disappears it is said to *pinch out*.
Pipe—Similar to a chimney, also the penetration of an upper bed into a lower one.
Pit—A shaft, also an open working in soft material.
Pitwork—The pumps and other appliances in the shaft.
Placer—An auriferous alluvial deposit.
Plat—An enlargement in a shaft.
Pocket—See *bunch*.
Pockety—See *bunchy*.
Post and Stall—See *pillar and stall*.
Pulp—In ore dressing, the product of the fine crushing of ore in the presence of water.
Punch-prop—A strut or distance-piece placed between the cribs in the temporary timbering of a shaft.
Putter—Trammer.
Pyritous—Containing pyrites.

QUARTZOSE—Consisting chiefly of quartz.

RAGGING—A heavier stage of spalling.
Raise, or Rise—A passage driven upwards in a mine.
Reef—A vein.
Riffles—Obstructions placed in the bottom of sluices, etc., to facilitate the deposition of gold, generally strips of wood.
Roof—The stratum immediately above a seam or bed.

SAFETY LAMP—A lamp in which dangerous contact between the external atmosphere and the flame is prevented by the use of wire gauze.
Sands—In ore dressing, the heavier products of hydraulic separators.
Seam—A tabular or sheet-like deposit forming one of a group of stratified rocks used in a more restricted sense than the term *bed*.
Set—A complete unit of framing in shaft or level timbering.
Shaft Pillar—A block of mineral left to support a shaft.
Shoading or Shoding—Tracing detached stones to the parent vein.
Shoe—See *stamp*.
Shoot—A continuous body of ore extending downwards; also a *pass*, or the lower end of a pass.
Sill—The bottom member or sole-piece of a set of timber in a level or drift.
Skip—A rectangular box, working in guides in the shaft, used for winding ore or rock, etc.
Skirting—A road driven alongside fallen stone.
Slide—A small fault or dislocation.
Slimes—In ore dressing, the lighter products of hydraulic separators.
Sludger—A cylinder with a valve at the bottom for removing crushed stuff from a bore hole.
Sluices—The large wooden troughs used as a channel for the stream of water and dirt in hydraulic mining.
Sole-piece—See *sill*.
Sollar—A platform in a shaft.
Spalling—Breaking down lumps of rock or ore with heavy hammers.
Spitzkasten — Inverted pyramidal boxes used in ore-dressing.
Spitzlutten—Double V-shaped troughs used in ore-dressing.
Sprags—Short props of timber.
Stamp—A weight used in comminuting ore, consisting of a *head* in which is fixed a replaceable *shoe* below and a *stem* above; the stem carries a *tappet* which is periodically engaged and released by a revolving *cam*, causing the stamp to rise and fall. The stamp works on a *die* in a narrow box called a *mortar*.
Stamping—The process of reduction by means of stamps.
Stanniferous—Containing tin.
Staple—An underground shaft or *winze*; also a small pit.
Stemming—Tamping.
Stockwork—A deposit consisting of a number of small veins or patches of ore near together.
Stoop and Room—See *pillar and stall*.
Stope—The place where the mineral is won in a vein mine.
Stopping—A wall built to stop the passage of air.
Stowing—Filling a place with waste.
Stratum—A bed or seam.
Strike—The direction a vein or bed takes across country.
Stringers or Strings—Thin branch veins.
Stringing Deals—Planks employed to hang curbs together in the temporary lining of a shaft.
Studdles—Timber struts or distance pieces used to keep the *sets* apart in shafts in vein mining.
Stulls—Timbers or platforms fixed in stopes for supporting waste rock.
Stythe—Carbonic acid gas.
Sump—The lowest part of the shaft; a drainage pit.
Sylvester—A very popular device for withdrawing timber from gob.

TAILINGS—The impoverished and discarded products of ore-dressing operations.
Tail Race—Channel for conveying away dirty water and tailings.
Tamping—The material used and the operation of filling up a bore hole in front of the charge of explosive.
Tappet—See *stamp*.
Thill—The floor of a mine.
Throw—The vertical displacement of a seam by a fault.
Timbering—Fixing timbers to keep excavations free from obstruction by falls of stone.
Tinstone—Ordinary tin ore.
Trammer—A man who does the tramming of mineral and works the tubs.
Trend—Strike.
Tributers—Miners who work for a percentage of the profits.
Trommel—A revolving screen.
Tubbing—A continuous water-tight lining of a shaft.
Tut work—Contract piece work.

UNDERCUTTING—Holing beneath or at the bottom of a seam.
Underhand Stoping—Working out a vein downwards; the reverse to overhand stoping.
Underlie—Synonymous with *hade*.
Unstratified Rocks—Rocks not occurring in regular beds or strata.
Upcast—The shaft for conveying the vitiated air out of a mine.
Upthrow—The upward displacement of a seam by a fault.

VANNING—Separating ore from veinstuff by washing on a shovel.
Veinstone—The worthless material in a vein.
Veinstuff—Same as *veinstone, gangue*, or *matrix*.

WALLS—The sides of a vein.
Wash-out—A portion of a seam that has been denuded, also called a *dumb fault*.
Whim—See *gin*.
Whip—A winding pulley.
White Damp—Steam, carbonic oxide, and carbonic acid gas.
Whits—Partly dressed tin ore.
Winding Engine—An engine used for drawing mineral, etc., up a shaft.
Winze—A shaft extending from level to level.
Working in the Broken—Removing or *robbing* the pillars in the pillar and stall method.
Working in the Whole—Forming pillars by roads driven at right angles to each other, in the pillar and stall method of working.

THE SELF-EDUCATOR AT A GLANCE

All the articles in the Self-Educator are briefly summarised in the following pages, under the groups, sub-groups, and sections to which they belong and in order of publication. This affords a brief general survey of the branches of knowledge and also gives an easy means of obtaining a general idea of the scope and nature of the articles. Sections of the groups are indicated by sub-headings in black. For particular subjects or items of information, reference should be made to the General Index, beginning on page 6223. A list of plates and frontispieces is given on page 6222.

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ERRATA—CORRECTIONS IN THE SEVEN VOLUMES OF THE EDUCATOR

VOLUME 1

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5 line 2. For "what," read "which."

9 Heading. For "daily," read "annual."

70 Picture is upside down.

232 col. 1, line 3. For 35,000,000, read 8,750,000.

359 Szerelmey's Stone Liquid. See note p. 1277, col. 2.

471 col. 2. At end of second paragraph, for "22 seconds every century," read "one-hundredth of a second in a century." See page 1697, col. 1.

698 col. 2, last paragraph. Read "We have noticed that the fat is formed into a soapy emulsion," etc. Delete "An emulsion is . . . an alkali."

VOLUME 2

1008 col. 2, par. 3, line 6. For "gliding," read "sliding."

1012 col. 1. Black type. For "Magnet circuit," read "Magnetic circuit."

1075 col. 2, Devon and Cornwall, line 8. Read "to grow up. At Axminster, in South Devon, long ago famous for its carpets, the most important industry is the making of toilet brushes and similar goods."

1096 col. 2, par. 3. Read "Davy obtained sodium by passing a very powerful current of electricity through the caustic soda (NaOH). The metal is now prepared in a different manner by electrolysis of fused caustic soda, or of the mixed chlorides of sodium, potassium, and strontium."

1149 col. 2, line 3. Read "a much larger number of slots."

1150 col. 2, line 18. Read "No. 1 and" not "in."

1152 col. 2, line 13. Read "RPM÷60."

1200 col. 2, No. 12. For "5 mls. 5 fur. 10 chains," read "5 mls. 5 fur. 7 chains."

col. 2. Examples 12, No. 2. Read

$$21\ 923636 - 9{\cdot}3893 = 12{\cdot}534297702743247$$

1229 col. 3, par. 3. Delete "with tin it forms bronze."

1289 Fig. 91. Replace "C" by "I."

1290 col. 1, line 1. For "95°," read "85°."

col. 2. In the tables, replace "C" by "I."

1316 col. 2, Ex. XIII. Vocabulary. For "to dine—*Cenar*," read "to lunch—*Comer*." Sentence 12: "I have not lunched yet."

1402 col. 2. Delete reference to "Plex" Sealing Machine.

1426 col. 2, black type. Read "Acid Test for Wool and Silk."

1580 col. 2. Key to Ex. XIII. Sentence 13. For "cenado," read "comido."

1787 col. 2. Delete reference to Sleeper, the Boston Humbug. His book has been proved to be a clever forgery.

PAGE

1851 col. 1, line 17. For "6 in.," read "6 ft."

VOLUME 3

2036 col. 2, line 2. "For "Severn," read "Avon."

VOLUME 4

3053 col. 1. Alberta and Saskatchewan, line 3. For "states," read "provinces."

3066 The table assumes that milk is divided into whey, buttermilk, etc., in the course of dairying, and consists of water, fat, casein, sugar, and ash. Of the water, 78·9 per cent. goes to the whey, 14 per cent. to the buttermilk, and so on. Similarly for the other columns.

3076 col. 1. For "Fernando," read "Hernando."

3182 col. 2, line 33. For "months," read "chapters."

3407 col. 2, last line. Read "Santiago del Estero."

3417 col. 2, line 15. For "1500 litres," read "1500 grams."

VOLUME 5

3837 The top picture is upside down.

3868 col. 2, line 8. Read "Rinde"

3926 col. 1, line 25. For "Bunan Varilla," read "Bunau Varilla."

4287 col. 2. Four lines from bottom. For "magnetism," read "magnesium."

4304 col. 1, lines 7, 8, 9. Read respectively "12A, 12B, 12C."

4306 fig. 12. The doorplate C should be shown attached to A, not B. The door could not open as shown.

VOLUME 6

4539 col. 1, line 6. Frenchman.

4686 fig. 3. For "Hydraulic Cranes," read "Hydraulic Presses."

4813 fig. 9. For "Crankpins," read "a crankshaft."

4816 fig. 12. Delete "Rear axle with."

5014 fig. 12. Read "Three-Roll Calender."

5117 last line but one. Read "but tend rather."

5214 col. 1, line 11. For "John," read "Joseph."

VOLUME 7

5432 col. 2, line 6. For "Indria," read "Idria."

5567 col. 2, line 23, For "pinnerettes," read "spinnerettes." Line 30, "liquid."

5807 col. 2, line 17, for "1904," read "1912"

5896 fig. 17. Read "One coil transformer."

5932 col. 2, under Cotton. Read "21,648,000 centals came from the United States, Egypt supplying 4,912,000 centals."

GENERAL INDEX TO THE SELF-EDUCATOR

The SELF-EDUCATOR is paged continuously through all its volumes, and the first and last pages in each volume are stamped on the backs of the volumes to facilitate instant reference. It is thus practically as easy to refer to any page in this seven-volume work as if it were a single volume.

This index is entirely alphabetical, and is arranged on the simplest possible lines. As far as is practicable, the grouping system has been avoided, in order that words might be given their proper place in the alphabet. Thus DYNAMO should be looked for under "D," and not under ELECTRICITY, though many words less familiar in common language are more conveniently placed under the general heading of ELECTRICITY. Chemical compounds are indexed thus, COPPER-SULPHATE, rather than SULPHATE OF COPPER. Unfamiliar minerals are given in the table on pages 4000-4014. Animals are also indexed under English in preference to Latin names.

Compound words and phrases are reckoned as one word, the order being, say—ACID, ACID EGG, ACIDITY, ACID LUTE, and so on. Parts of speech should be looked for under their respective languages: Verb in Latin, for example, under LATIN; adjective in French, under FRENCH, and so on. Figures in italics indicate illustrations.

Where several pages or chapters are devoted to one subject, the first page of the chapter only is indexed, but the arrangement of the EDUCATOR enables the chapters to be found with ease.

Technical terms and phrases not indexed are explained in the special dictionaries appearing in the sixty-four pages following page 6153.

The bibliography of 4000 books on all subjects embraced in the EDUCATOR is not indexed, as the arrangement of the books enables the reader to find quite easily any subject he wishes to consult.

The Editor offers an apology for any lack of completeness that may appear when the full work is compared with the promise with which it set out. Built up in parts as it appeared, and covering two years in its growth, the EDUCATOR shared in the general destruction that came upon Europe when the German Emperor walked out of civilisation. With a depleted staff, and in face of unparalleled difficulties that need not be explained, it became necessary to modify certain departments of the EDUCATOR, and a few subjects have received inadequate treatment. The Editor apologises for this misfortune, confident that it will be accepted as a minor part of the common sacrifice on the altar of civilisation and human liberty.

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